Endangered Species Act Section 7(a)(2) Biological Opinion

Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and the State Water Project

NMFS Consultation Number: WCR-2019-11484

Action Agencies: U.S. Bureau of Reclamation Affected Species and NMFS' Determinations:

ESA-Listed	Status	Is Action	Is Action	Is Action	Is Action
Species		Likely to	Likely To	Likely to	Likely To
wo.		Adversely	Jeopardize	Adversely	Destroy or
		Affect	the Species?	Affect	Adversely
		Species?		Critical	Modify Critical
		Med li		Habitat?	Habitat?
Sacramento River	Endangered	Yes	Yes	Yes	Yes
winter-run					
Chinook salmon					
(Oncorhynchus					
tshawytscha)				s	v .
Central Valley	Threatened	Yes	Yes	Yes	Yes
spring-run					
Chinook salmon					
(O. tshawytscha)		1701110			
California Central	Threatened	Yes	Yes	Yes	Yes
Valley steelhead					
(O. mykiss)					
Southern Distinct	Threatened	Yes	No	Yes	No
Population	Timeatened	103	140	103	140
Segment of North					
American green					
sturgeon					
(Acipenser					
medirostris)					
Southern	Endangered	Yes	Yes	N/A	N/A
Resident killer	Lindangorod	105	105	11/11	11/21
whale (Orcinus					
orca)					

Consultation Conducted By	: National Marine Fisheries Service, West Coast Region
Issued By:	Chris Oliver
	Assistant Administrator for NOAA Fisheries
Date : July 1, 2019	

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LIST OF ACRONYMS

ACID Anderson-Cottonwood Irrigation District

AFSP Anadromous Fish Screen Program

AR4 Fourth Assessment Report
AR5 Fifth Assessment Report
ARG American River Group
BA Biological Assessment

Bank
Banks
Liberty Island Conservation Bank
Harvey O. Banks Pumping Plant
BMP
best management practices
BSPP
Barker Slough Pumping Plant

CAMT Collaborative Adaptive Management Team

CCC Central California Coast
CCF Clifton Court Forebay

CCR Sacramento River above Clear Creek Gaging

Station

CCV California Central Valley
CCWD Contra Costa Water District

CDFG California Department of Fish and Game
CDFW California Department of Fish and Wildlife

CEQ Council on Environmental Quality
CESA California Endangered Species Act

cfs cubic feet per second

CHTR Collection, Hauling, Transport, Release
CMIP3 Coupled Model Intercomparison Project

COS Coleman National Fish Hatchery
COA Coordinated Operations Agreement
CURRENT Current Operations Scenario

CRR cohort replacement rate

CV Central Valley

CVP Central Valley Project

CVPIA Central Valley Project Improvement Act

CWP Cold Water Pool
CWT coded-wire tag

7DADM 7-day average daily maxima
DAT Daily Average Temperature

DCC Delta Cross Channel

DDT dDchlorodiphenyltrichloroethane
Delta Sacramento-San Joaquin Delta
DIDSON Dual-frequency identification sonar

DO Dissolved oxygen
DOI Department of Interior
DPM Delta Passage Model

DPS Distinct population segment

DQA Data Quality Act

DRERIP Delta Regional Ecosystem Restoration

Implementation Plan

DWR California Department of Water Resources

DWSC Deep Water Ship Channel

EBMUD East Bay Municipal Utility District
EIS Environmental Impact Statement

EFH Essential Fish Habitat EOS End of September

EPA Environmental Protection Agency ePTM enhanced particle tracking model

ESA Endangered Species Act
ESU Evolutionarily significant unit

FERC Federal Energy Regulatory Commission

FL Fork length

FRFH Feather River Fish Hatchery
GCID Glenn Colusa Irrigation District
GSI Genetic Stock Information

HGMP Hatchery Genetic Management Plan

HORB Head of Old River Barrier IGO Igo stream gaging station

IPCC Intergovernmental Panel on Climate Change
IOS Interactive Object-Oriented Simulation

ITS incidental take statement
JFP Joint Federal Project

JPE Juvenile production estimate KLRC Knights Landing Ridge Cut

KWK Keswick Gauge

LSNFH Livingston Stone National Fish Hatchery

LTO Long-term operations
LWD Large woody debris
LWM Large woody material
M&I Municipal and Industrial

MAF Million acre-feet

mm millimeter

MOU Memorandum of Understanding

MSA Magnuson-Stevens Fishery Conservation and

Management Act

Napa County FC&WCD Napa County Flood Contral and Water

Conservation District

NBA North Bay Aqueduct NCO Not Consulted On

NERC North American Electric Reliability

NFH National Fish Hatchery

NMFS National Marine Fisheries Service

NMFS 2009 Opinion NMFS' June 4, 2009 biological and conference

opinion on the Central Valley Project and State

Water Project

NTU Nephelometric Turbidity Unit
OHWL Ordinary high water line
OMR Old and Middle River
Opinion Biological Opinion
OTC Once Through Cooling
PA Proposed Action

Troposed redon

PA component An individual element of the Proposed Action

PAHs polycyclic aromatic hydrocarbons
PBF Physical or biological features
PCBs Polychlorinated biphenyls
PCE Primary Constituent Elements
PVA Population viability analysis

PWA Public Water Agency
RBDD Red Bluff Diversion Dam

RCP Representative Concentration Pathway

Reclamation U.S. Bureau of Reclamation

RK River kilometer
RM River Mile

ROC on LTO Reinitiation of Consultation on Long-Term

Operations

ROC on LTO BA Reclamation's 2019 BA for reinitiation

ROD Record of Decision

RPA Reasonable and Prudent Alternative
RPM Reasonable and Prudent Measures

RST Rotary screw trap

RWQCB Regional Water Quality Control Board

SAIL Salmon and Sturgeon Assessment of Indicators by

Life stage

SCWD Solano County Water District

SDFPF Skinner Delta Fish Protection Facility sDPS Southern Distinct Population Segment

SGMA California Sustainable Groundwater Management

Act

SI Sacramento Index

SIT Science Integration Team

SJRRP San Joaquin River Restoration Program
SMSCG Suisun Marsh Salinity Control Gates

SONCC Southern Oregon/Northern California Coast

SRA Shaded Riparian Aquatic

SRKW Southern Resident Killer Whale

SRTTG Sacramento River Temperature Task Group

SRWTP Sacramento Regional Wastewater Treatment Plant

SWE Snow Water Equivalents

SWFSC Southwest Fisheries Science Center

SWP State Water Project

SWRCB State Water Resources Control Board

SWRI Surface Water Resources, Inc.

TAF Thousand acre-feet

TFCF Tracy Fish Collection Facility
TCD Temperature Control Device
TCP Temperature compliance point

TRD Trinity River Division
TRT Technical Review Team
USFS United States Forest Service

USFWS United States Fish and Wildlife Service

VSP Viable salmonid population
WCVI West Coast Vancouver Island
WDR Waste Discharge Requirements

WOA Without action

WRLCM Winter-run Chinook Salmon Life Cycle Model

WRO Water rights order
WUA weighted usable area
YOY Young-of-the-year

1 INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) prepared the biological opinion (Opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR Part 402.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554).

1.2 Coordinated Operations Agreement

In November 1986, the United States, through the Bureau of Reclamation (Reclamation), and the California Department of Water Resources (DWR) signed the Coordinated Operations Agreement (COA), which defines the rights and responsibilities of the Central Valley Project and State Water Project (CVP/SWP) with respect to in-basin water needs and provides a mechanism to account for those rights and responsibilities. Congress, through Public Law 99-546, authorized and directed the Secretary of the Interior to execute and implement the COA. Under the COA, Reclamation and DWR agree to operate the CVP and SWP, respectively, under balanced conditions in a manner that meets Sacramento Valley and Delta needs while maintaining their respective water supplies, as identified in the COA. "Balanced conditions" are defined as periods when the CVP and SWP agree that releases from upstream reservoirs, plus unregulated flow, approximately equal water supply needed to meet Sacramento Valley in-basin uses and CVP/SWP exports. The COA is the Federal nexus for ESA section 7 consultation on operations of the SWP. In this Reinitiation of Consultation on Long-Term Operations (ROC on LTO), DWR is considered an applicant.

In 2018, Reclamation and DWR modified four key elements of the COA to address changes since it was originally signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 acre-feet per year; and (4) the periodic review. Full details are provided in the ROC on LTO Biological Assessment (BA), Appendix A, pages A-127 to A-130. COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80 percent responsibility of the United States and 20 percent responsibility of the State of California in wet year types to 60 percent responsibility of the United States and 40 percent responsibility of the State of California in critical year types. In a dry or critical year following two dry or critical years, the United States and State will meet to discuss additional changes to the percentage sharing of responsibility to meet in-basin use. When exports are constrained and the Delta is in balanced conditions, Reclamation may pump up to 65 percent of the allowable total exports with DWR pumping the remaining capacity. In excess conditions, these percentages change to 60 percent United States and 40 percent State.

1.3 Key Consultation Considerations

1.3.1 Trinity River Division

Although the Trinity River Division (TRD) is part of the Central Valley Project, in its April 30, 2019, revised BA (Appendix A2), Reclamation removed all action components associated with the Trinity River portion of the TRD. The remaining PA components of the TRD are associated with transbasin diversions into Whiskeytown Reservoir. As a result, NMFS did not analyze any aspects of the proposed action on the Trinity and Klamath rivers, or their associated listed species (i.e., Pacific eulachon, Southern Oregon/Northern California Coast coho salmon) and designated critical habitats. Neither was production of currently-unlisted Upper Klamath-Trinity River Chinook salmon evaluated as it pertains to Chinook salmon availability as prey for Southern Resident killer whales (SRKW).

1.3.2 ESA Consultation on CVP and SWP Hatcheries

CVP and SWP hatcheries within the Central Valley include the Livingston Stone National Fish Hatchery (LSNFH), Coleman National Fish Hatchery (CNFH), Feather River Fish Hatchery (FRFH), and Nimbus Fish Hatchery. Since production from these hatcheries are to mitigate lost habitat from the construction of CVP and SWP dams, which are components of the environmental baseline, the production from these hatcheries is also included in the environmental baseline.

There is one exception to the above consultation consideration on CVP hatcheries. Reclamation included in its PA that it will complete a Hatchery Genetic Management Plan (HGMP) for steelhead and a hatchery management plan for fall-run Chinook salmon for Nimbus Fish Hatchery. Completing an HGMP is a process that will begin when a draft is sent to NMFS for review and to begin consultation. In this Opinion, we consider the effects from the HGMP at the Framework-level.

1.3.3 ESA Consultation Linkage to the Operation of Oroville Dam

The Oroville Complex (Oroville Dam and related facilities, including the FRFH) is part of the SWP. DWR has been operating the Oroville Complex under a Federal Energy Regulatory Commission (FERC) license and is currently undergoing a relicensing process with FERC (FERC Project No. 2100-134). The FERC license expired in January 2007, and until a new license is issued, DWR operates to the existing FERC license. On December 5, 2016, NMFS completed the section 7 consultation and issued a biological opinion to FERC regarding the effects of relicensing the Oroville Complex for 50 years. That biological opinion analyzes the effects of the proposed relicensing of the Oroville Facilities in the Feather River and the effects of FRFH salmonid strays in the Sacramento River watershed. Because the effects of the Oroville Complex were considered in the biological opinion to FERC, the effects of operation of Oroville Dam on listed fish within the Feather River are considered in the environmental baseline for this consultation.

1.3.4 Individual Contracts except to Sacramento River Settlement Contractors

This consultation addresses the long-term operations of the CVP and SWP, and does not satisfy Reclamation's ESA section 7(a)(2) obligations for issuance of individual water supply contracts,

except to the Sacramento River Settlement Contractors. Reclamation should consult with NMFS separately on their issuance of individual contracts. The analysis of effects of the proposed action, however, assumes water deliveries under the contracts, as described and modeled in the BA.

NMFS requests that by June 17, 2020, Reclamation provide written notification to NMFS and the State Water Resources Control Board (SWRCB) of any contract that it believes creates a nondiscretionary obligation to deliver water, including the basis for this determination and the quantity of nondiscretionary water delivery required by the contract. Any incidental take due to delivery of water to such a contractor (except Sacramento River Settlement Contractors) is not exempt from the ESA section 9 take prohibition in this Opinion.

1.3.5 Non-Discretionary Contracts

Reclamation proposes to operate the CVP (and DWR for the SWP) to deliver water under the terms of all existing contracts (but not execute any new contracts or amend any existing contracts as part of this consultation) up to full contract amounts, which includes the impacts of maximum water deliveries and diversions under the terms of existing contracts and agreements, including timing and allocation (see ROC on LTO BA Section 4.4 CVP Water Contracts). The contracts include water service and water repayment contracts, as well as settlement, exchange, and refuge contracts. In addition, it includes water delivery through temporary, not to exceed 1 year, "Section 215 Contracts," when there are surplus flood flows, and the conveyance of non-CVP (which includes SWP) water when there is excess capacity available in CVP facilities (pursuant to the Warren Act). Finally, Reclamation proposes to operate the CVP to meet its obligations to deliver water to senior water right holders who received water prior to construction of the CVP, to wildlife refuge areas identified in the CVPIA, and to water service contractors.

1.3.6 Peer Review of NMFS Draft CVP/SWP Operations Opinion

NMFS sought peer reviews of its draft ROC on LTO Opinion through a contract with Anchor QEA. Three reviewers, Dr. Dave Hankin (Professor Emeritus, Humboldt State University, Dr. Kenneth Rose (Professor, University of Maryland Center for Environmental Science), and Dr. John Skalski (Professor, School of Aquatic and Fishery Sciences, University of Washington), were selected from a pool of 33 potential reviewers, based on availability, knowledge, and experience. The panel reviewed the Analytical Approach through Effects sections of the draft opinion for all ESA-listed species and their critical habitats. The reviewers received relevant background information and supplemental materials to consider in their reviews. NMFS was available for a conference call during the review period to respond to questions or address clarification needs during the reviews. Reviewers were expected to convene at least one conference call to discuss major findings and identify and attempt to rectify any conflicting guidance.

As a result of the Opinion deadline extension to July 1, 2019 (see Section 1.4.10) and the resulting revised/delayed period of performance, and the daunting amount of materials to be reviewed in the short review period, on June 9, 2019, Dr. Hankin informed Anchor QEA that he would not be able to continue on with the review.

On June 14, 2019, the peer reviewers issued their individual reports and findings to Anchor QEA and NMFS, according to the format provided by the hiring contractor. Each of the peer review

reports had constructive recommendations towards the development of a more scientifically robust final Opinion. However, in general, all of the peer reviewers and their reports acknowledged the incredibly complex proposed action, and that NMFS applied the best available information in its development of the draft Opinion. This Opinion, and its supporting administrative record, considered and/or incorporated all of the substantive peer review recommendations, as appropriate.

1.3.7 "Not Consulted On"

Table 4-6 of the ROC on LTO BA identifies each of the components of the proposed action for the subject consultation. Reclamation characterized completed consultations with existing biological opinions that address the effects of long-term operations and do not trigger reinitiation under this consultation are identified by "NCO" (Not Consulted On). Therefore, all components that are characterized as NCO were not considered as part of the proposed action nor effects of the action in this consultation.

1.3.8 Without Action Scenario

The ROC on LTO BA, Environmental Baseline Section 3.3, describes a "without-action" (WOA) scenario that does not include any past or current CVP or SWP operations. Reclamation provided this WOA scenario that includes the existence of the dams and south Delta facilities, but does not include description of past or current operations of these facilities. This WOA scenario is a useful analytical tool to separate some of the effects related to the existence of CVP and SWP facilities and provides context for how these facilities have shaped the habitat conditions for species and critical habitat in the action area. The WOA scenario also provides a useful context for understanding that Reclamation and DWR exercise a broad range of discretion over the operations of the CVP and SWP. Specifically, the ROC on LTO BA describes the WOA scenario as:

"...in a consultation on an ongoing action, the without-action scenario cannot be defined by simply projecting the status quo into the future, because doing so would improperly include in the baseline the continued effects of the action under consultation. Instead, in a consultation on an ongoing action, such as operation of the CVP and SWP, the baseline analysis must project a future condition without the action. This allows for isolation of the effects of the action from the without-action scenario and, in turn, a determination of whether the action is likely to jeopardize listed species and/or destroy or adversely modify critical habitat. Thus, to provide a snapshot of the species' survival and recovery prospects without the proposed action, Reclamation is analyzing a without-action scenario. The without-action scenario entails no future operations of the CVP and SWP: in other words, no discretionary regulation of flows through the system, including, for example, storing and releasing water from reservoirs and delivering water otherwise required by contract."

In addition, through modeling, the ROC on LTO BA, Section 5.5 Effects of the Action, uses the WOA scenario in order to compare the effects of the PA against the WOA scenario.

As described in Section 2.4, of this Opinion, the environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02 2007). In this Opinion, the effects of past CVP/SWP operations are also part of the environmental baseline. Effects of those actions have been analyzed through past consultation and contributed to the current condition of the species and critical habitat in the action area. Other past, present, and ongoing impacts of human and natural factors (including proposed Federal projects that have already undergone section 7 consultation) contributing to the current condition of the species and critical habitat in the action area are also included in the environmental baseline.

It is important to note that for ESA section 7, each time the operations of the CVP and SWP are consulted on (e.g., 2004 and 2008/2009), the impacts of past and present operations of the CVP and SWP become part of the environmental baseline for subsequent consultations. The operations of the CVP and SWP over time is not one continuous Federal action in the context of ESA compliance. Rather, the CVP and SWP action described and analyzed in the 2004 biological opinion was discrete from the CVP and SWP action described and analyzed in 2008/2009, which again, is discrete from the proposed CVP and SWP action analyzed in this Opinion. In other words, each PA had specific components and operating criteria, and were therefore separate Federal actions requiring separate ESA section 7 consultations and analyses.

1.3.9 Operations with Shasta Dam Raise

Reclamation has proposed to operate the CVP and Shasta Reservoir after the Shasta Dam raise construction has been completed (current estimate is 10 years for construction). Operations with the Shasta Dam raise was not modeled nor included in the ROC on LTO BA. However, Reclamation has stated that operations with Shasta Dam raise will not change from the modeling of operations without the Shasta Dam raise. Therefore, NMFS will also make the assumption in the effects of the action, that operations will not change with the Shasta Dam raise. One of the conditions of reinitiation of consultation in the interagency cooperation governing section 7 consultations (50 CFR 402.16) is "If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered." Therefore, NMFS has provided a specific reinitiation of consultation trigger in section 2.13 to address the potential that operations with the Shasta Dam raise result in effects to the listed species or critical habitat in a manner or to an extent not considered in this Opinion.

1.3.10 Treatment of CV Spring-Run Chinook Salmon in the San Joaquin River Restoration Program

In 2013, NMFS designated a non-essential experimental population of CV spring-run Chinook salmon for reintroduction to the San Joaquin River in accordance with section 10(j) of the ESA (78 FR 79622 2013). This designation allows for the release of listed CV spring-run Chinook salmon outside their current range as an experimental population; given that, the non-essential population is geographically separate from the threatened population of the same species and if lost, will not significantly impact the status of that species. In addition, ESA section 4(d) provides protective regulations including ESA section 9 take exceptions for activities preformed during otherwise lawful activities within the experimental population area. Any activities that

result in direct intentional take, harm, or activities that are illegal in nature are still subject to ESA section 9 provisions. The 10(j) rule has allowed the San Joaquin River Restoration Program (SJRRP) to begin reintroduction efforts in the restoration area while still meeting the San Joaquin River Restoration Settlement Act's (Settlement Act) requirement of no more than *de minimus* water supply impacts to third parties.

The Settlement Act states in section 10011(c)(3) that the reintroduction of CV spring-run Chinook by the SJRRP will not impose more than *de minimus* water supply reductions, additional water storage releases, or bypass flows on unwilling third parties due to the reintroduction. Outside of the reintroduction area, CV spring-run Chinook salmon in the San Joaquin River or its tributaries downstream to Mossdale County Park in San Joaquin County will continue to be covered by the same take prohibitions and exceptions applicable to non-experimental populations, except when potential regulatory measures to address take would affect the *de minimus* conditions of the Settlement Act. Section 10011(c) of the Settlement Act includes the Central Valley Project contractors outside of the Friant Unit and State Water Project in the definition of "third parties," and NMFS develops an annual technical memorandum to describe the accounting of any experimental non-essential CV spring-run Chinook salmon during the operations of these facilities. That report can be found on the NMFS San Joaquin River Restoration website.

1.3.11 White House Memorandum on "Promoting the Reliable Supply and Delivery of Water in the West"

On October 19, 2018, the White House issued a memorandum titled, "Promoting the Reliable Supply and Delivery of Water in the West". The key excerpts pertaining to this ROC on LTO consultation include:

"Section 2(c)(ii): The Secretary of the Interior shall issue final biological assessments for the long-term coordinated operations of the Central Valley Project and the California State Water Project not later than January 31, 2019.

Section 2(c)(iii): The Secretary of the Interior and the Secretary of Commerce shall ensure the issuance of their respective final biological opinions for the long-term coordinated operations of the Central Valley Project and the California State Water Project within 135 days of the deadline provided in section 2(c)(ii) of this memorandum. To the extent practicable and consistent with law, these shall be joint opinions."

The Council on Environmental Quality (CEQ) granted NMFS a 2-week extension to July 1, 2019, to issue a final Opinion.

1.3.12 Water Infrastructure Improvement for the Nation Act

Section 4004 of the Water Infrastructure Improvement for the Nation Act of 2016 requires the Secretary of Commerce to ensure "that any public water agency that contracts for the delivery of water from the Central Valley Project or the State Water Project that so requests shall "receive a copy of any draft biological opinion and have the opportunity to review that document and provide comment to the consulting agency through the action agency, which comments will be afforded due consideration during the consultation." The Analytical Approach through Effects sections were shared with the public water agencies (PWAs) through Reclamation on June 3,

2019. The PWAs provided written comments on the draft biological opinion on June 14, 2019, through Reclamation, which were afforded due consideration during the consultation.

1.3.13 Term of the Opinion

This Opinion is effective through December 31, 2030, and is subject to the reinitiation of consultation triggers in Section 2.13 and at 50 CFR 402.16. However, if conditions past 2030 are similar to the analysis period, this opinion can remain in effect.

1.4 Consultation History

On October 22, 2004, NMFS issued its Opinion on the proposed CVP/SWP operations (National Marine Fisheries Service 2004). On June 4, 2009, NMFS issued its Opinion and conference opinion on the proposed CVP/SWP operations (NMFS 2009 Opinion)(National Marine Fisheries Service 2009b), that superseded the 2004 opinion. Within the NMFS 2004 Opinion and the NMFS 2009 Opinion were consultation histories ranging from February 1991 to June 2004 and April 2006 to January 2009, respectively, which are incorporated here by reference. Table 1.4-1 [Section 1.4 of ROC on LTO BA (Reclamation 2019)], provides a summary of the consultation history from February 1992 through January 2019.

Table 1.4-1. Consultation History tabulated in ROC on LTO BA (Reclamation 2019)

Date	Issuer	Document	Rationale for Consultation	Subject/ Species	Finding
February 1992	USBR	Interim Central Valley Project Operations Criteria and Plan		OCAP	
June 1993	NMFS	ВО	Winter-Run listed in 1991	Winter-Run Chinook Salmon	Jeopardy
March 1995	USFWS	ВО	Delta Smelt listed in March 1993; Splittail proposed in 1994	Delta Smelt and Splittail	Non-Jeopardy
June 2004	USBR	BA	Combined ESA species consultation in one assessment	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Coho Salmon, Delta Smelt	Likely to Adversely Affect: Winter-run, Spring-run, CV Steelhead; May Affect/Not Likely to Adversely Affect: Coho, Delta Smelt
July 2004	USFWS	во	Coordinate with combined NMFS ESA species consultation	Delta Smelt	Non-Jeopardy
October 2004	NMFS	ВО	Combined ESA species consultation	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Coho Salmon	Non-Jeopardy
May 2008	USBR	ВА	Green Sturgeon was listed in 2006; Pelagic Organism Decline	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon,	Adversely Affect: Delta Smelt; LAA: CV steelhead, Winter-run, Spring-

Date	Issuer	Document	Rationale for Consultation	Subject/ Species	Finding
				Steelhead, Green Sturgeon, Coho Salmon, Delta Smelt	run; Green Sturgeon; NLAA: Coho Salmon
December 2008	USFWS	ВО	Pelagic Organism Decline; conflicts with Sturgeon	Delta Smelt	Jeopardy
June 2009	NMFS	BO and Conference Opinion	Green Sturgeon listed in 2006	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon*	Jeopardy and Adverse Mod
January 2019	USBR	ВА	Drought; New Science; Declining status	Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Steelhead, Green Sturgeon, Coho, Delta Smelt*	See Effects Determination in the BA

^{*}Southern Resident killer whales were also part of the consultations, but their critical habitat is not in the action area.

On August 2, 2016, the Reclamation requested ESA section 7 reinitiation of consultation on the CVP/SWP, ROC on LTO based on new information related to multiple years of drought, recent data demonstrating extremely low listed-salmonid population levels for the endangered winterrun Chinook salmon, and new information available and expected to become available as a result of ongoing work through collaborative science processes. On August 17, 2016, NMFS responded, indicating that this type of operations consultation is most efficiently done with participation of multiple agencies, including Reclamation, DWR, California Department of Fish and Wildlife (CDFW), and the U.S. Fish and Wildlife Service (USFWS), along with NMFS (collectively "five agencies"). In addition, NMFS indicated staff resource constraints and inability to begin work on the ROC on LTO until the California WaterFix Opinion and the Shasta Reasonable and Prudent Alternative (RPA) adjustment efforts were completed. NMFS issued the California WaterFix Opinion to Reclamation and DWR on June 16, 2017, and issued a draft proposed Shasta RPA amendment to Reclamation on January 19, 2017.

From February 2017 through June 2018, Reclamation convened a five agencies ROC on LTO Core Team, with biweekly meetings to work through various issues associated with the ROC on LTO, for example, duration of the proposed action, environmental baseline, and inclusion (or not) of operations associated with California WaterFix. The five agencies Core Team also developed background and process materials in preparation for brainstorming meetings.

From June 2017 through January 2018, Reclamation led five-agency (plus watershed tribes and Western Area Power Administration representatives) brainstorming workshops within each CVP-controlled stream geographic area to help Reclamation develop National Environmental Protection Act alternatives for the reinitiation.

In November 2017, Reclamation advised the ROC on LTO Core Team of the Department of the Interior's (DOI) direction to pursue 3 tracks to completing the reinitiated consultation. In the fall of 2018, Reclamation acknowledged that the actions proposed in Track 1 had substantial controversy, likely would not result in "not likely to adversely affect" determinations, and ESA compliance likely would not be completed within calendar year 2018. Reclamation, therefore, did not pursue Track 1 for ESA consultation and compliance. Because of a substantial effort towards Track 1, not much effort was spent on Track 2. Reclamation subsequently decided that Tracks 2 and 3 would be combined into the ROC on LTO.

On October 19, 2018, the White House issued a memorandum titled, "Promoting the Reliable Supply and Delivery of Water in the West". The key excerpts pertaining to the CVP/SWP operations consultation include:

"Section 2(c)(ii): The Secretary of the Interior shall issue final biological assessments for the long-term coordinated operations of the Central Valley Project and the California State Water Project not later than January 31, 2019.

Section 2(c)(iii): The Secretary of the Interior and the Secretary of Commerce shall ensure the issuance of their respective final biological opinions for the long-term coordinated operations of the Central Valley Project and the California State Water Project within 135 days of the deadline provided in section 2(c)(ii) of this memorandum. To the extent practicable and consistent with law, these shall be joint opinions."

Throughout November and December, 2018, NMFS provided Reclamation with technical assistance towards their development of a BA for the ROC on LTO.

NMFS was affected by the partial Federal government shutdown from December 22, 2018, through January 25, 2019, precluding any further technical assistance from NMFS staff, including the opportunity to review much of the draft BA effects analyses prior to finalization on January 31, 2019.

On January 31, 2019, Reclamation submitted a letter, transmitting an enclosed BA to NMFS, requesting the ROC on LTO and its effects on:

- Sacramento River winter-run Chinook salmon (Oncorhynchus tshawytscha) and their designated critical habitat,
- Central Valley spring-run Chinook salmon (O. tshawytscha) and their designated critical habitat,
- California Central Valley (CCV) steelhead (O. mykiss) and their designated critical habitat,
- Southern Distinct Population Segment (sDPS) of North American green sturgeon (*Acipenser medirostris*) and their designated critical habitat,
- Southern Oregon/Northern California Coast (SONCC) coho salmon (O. kisutch) and their designated critical habitat,
- Southern DPS of eulachon (Thaleichthys pacificus) and their designated critical habitat, and,

• Southern Resident killer whales (SRKW) (Orcinus orca).

Reclamation made "no effect" determinations on Central California Coast (CCC) steelhead (O. mykiss) and their designated critical habitat. Therefore, is not requesting initiation of section 7 consultation for CCC steelhead or their designated critical habitat.

In addition, Reclamation made the following effect determinations for essential fish habitats (EFH):

- Would adversely affect:
 - Pacific Coast Salmon
 - Pacific Coast Groundfish
- Not likely to adversely affect:
 - Coastal Pelagic Species

Therefore, Reclamation also requested EFH consultation pursuant to the Magnuson-Stevens Fishery Conservation and Management Act of 1976.

On February 5, 2019, Reclamation informed DWR, CDFW, USFWS, and NMFS that a final version of the CVP/SWP Operations BA had been posted to Reclamation's website.

From February 5 to February 21, 2019, NMFS completed its initial review of the final BA. On February 22, 2019, NMFS sent to the five agencies a list of the most important comments associated with the proposed action and effects of the action. On February 22, 2019, the five agencies convened an all-day meeting to discuss the most important issues in the BA associated with Shasta Reservoir and Delta operations, in particular. Follow-up meetings for the Trinity River, Clear Creek, Feather River, American River, the Delta, and the Stanislaus River were scheduled for the week of February 27, 2019. Follow-up meetings for storage management and allocations, and seasonal temperature management modeling, were scheduled for March 5 and March 12, 2019, respectively.

NMFS requested and Reclamation provided results for the following: (1) Additional DSM2-HYDRO analyses, (2) CalSimII model, (3) HEC-5Q temperature model, (4) RBM-10 temperature model, (5) Sacramento River egg mortality models (both Anderson and Martin), (6) Delta Passage Model, (7) IOS model, (8) Central Valley Project Improvement Act (CVPIA) Science Integration Team (SIT) survival relationships, (9) Salvage-Density Method, (10) SALMOD, (11) Weighted usable area analyses, (12) Trinity Stream Salmonid Simulator model, and (13) Coho salmon habitat modeling. Reclamation submitted to NMFS the last of the model results on April 5, 2019.

On March 25, 2019, Reclamation withdrew all actions associated with the Trinity River from their proposed action (e.g., seasonal operations, Grass Valley Creek, and lower Klamath fall flow augmentation). The only components remaining within the Trinity River Division in the proposed action were operations associated with Whiskeytown Reservoir and Clear Creek, and the Spring Creek Debris Dam.

On April 1, 2019, in preparation for a water user forum meeting, Reclamation distributed via email a revised PA that included track changes compared to the February 5, 2019, version. On April 19, 2019, Reclamation informed NMFS that the ROC on LTO BA and Appendix E was

updated on Reclamation's website. NMFS requested a track changes version of the BA, as we did not have time to compare the two documents to identify the changes. On April 30, 2019, Reclamation sent NMFS an e-mail, transmitting the April 19, 2019, revised PA in track changes, compared to the February 5, 2019, version of the PA (Appendix A2). Revisions include inclusion (or removal) of PA components (e.g., revised PA Table 4-6), clarification of PA components (e.g., 4.10.1.4 Fall and Winter Refill and Redd Maintenance), and more complete description of PA components (e.g., Section 4.10.5.8 Clifton Court Aquatic Weed and Algal Bloom Management).

On May 16, 2019, CEQ granted NMFS a 2-week extension to July 1, 2019, to issue a final biological opinion.

In the interest of meeting expectations within the White House's October 19, 2018, memorandum on "Promoting the Reliable Supply and Delivery of Water in the West," from May 9 to May 23, NMFS distributed various sections of the draft biological opinion to NOAA General Counsel and the Department of the Interior's (DOI) Solicitors, including the Status of the Species and Critical Habitats, Environmental Baseline, effects of the action on listed species and designated critical habitats, and integration and synthesis. From May 14 through May 24, DOI Solicitors provided comments back on the sections. On May 21, 22, and 24, NMFS, Reclamation, and the USFWS met to talk through Reclamation's main comments, especially those that pertained to its PA. Reclamation offered clarifications during the meetings, that were later reflected in the deconstructed action sections within each division in the effects section. In addition, on May 29, 2019, NMFS received a more detailed description of the PA component Spring Creek Debris Dam. Meetings continued through June 11 to work through performance measures for the Shasta Division, with the objective to develop and manage toward tier-based temperature-dependent egg mortality and total egg-to-fry survival levels with periodic independent reviews; performance measures for the Delta Division, with the objective to bound the loss of salmon and steelhead at the export facilities to not exceed loss levels over the past 10 years with periodic independent reviews; and other issues, including consideration of systemwide drought management plan to confer on actions necessary to minimize effects. Multiple drafts of sections of the Opinion were shared with the Department of the Interior from May 29 through June 21, 2019. A final PA was issued to NMFS on June 14, 2019.

1.5 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02 2007).

In this case, Reclamation, with DWR, have requested ROC on LTO of the CVP and SWP to maximize water supply delivery and optimize power generation consistent with applicable laws, contractual obligations, and agreements. It is also Reclamation's stated goal to increase operational flexibility by focusing on non-operational measures to avoid significant adverse effects, based on the conditions estimated to occur through 2030.

The PA for this consultation is a "mixed programmatic" action as defined by 80 FR 26832 (2015) because it includes some action components for which no additional authorization will be necessary, and others that are considered at a "framework-level". The components that require no additional authorization are analyzed in this Opinion, and exemption from take prohibitions is provided in the ITS of this Opinion. The other action components that are considered at a

framework-level are also analyzed in this Opinion, but with a broader scale of examination of the components' potential impacts on listed species and critical habitat. Exemption from take prohibitions for these components is not provided in the ITS of this Opinion. Once framework-level action components are further developed to provide sufficient detail for take determination, they will require additional ESA section 7 consultation before implementation; and this subsequent consultation will include an ITS for those components.

Regardless of the timing of the individual action components, the operation of the CVP is coordinated with the SWP to achieve the intended project purposes according to CVPIA [Pub. L. No. 102-575, 106 Stat. 4706 (1992)]. The CVP and SWP are two major inter-basin water storage and delivery systems that capture, retain, release, and divert water primarily from the northern portion of the state for export south of the Sacramento-San Joaquin Delta (Delta). The CVP's major storage facilities are Shasta, Trinity, Folsom and New Melones reservoirs, while the SWP primarily relies on Lake Oroville. These upstream reservoirs are operated to provide water for the Delta, which can then be exported, either by the CVP through the Jones Pumping Plant, or by the SWP through the Harvey O. Banks Pumping Plant (Banks), to be stored in the joint San Luis Reservoir. In addition, exported water can be delivered via either the Delta Mendota Canal (part of CVP), or the California Aqueduct (part of SWP). The continued, coordinated LTO of the CVP and SWP facilities (the PA subject of this Opinion) is described in detail in Chapter 4 of the ROC on LTO BA, as transmitted on January 31, 2019, and uploaded onto Reclamation's Bay-Delta Office website on February 5, 2019. Additional clarifications to the PA were provided by Reclamation and are included in the revised/supplemental PA transmitted to NMFS on April 30, 2019 (Appendix A2).

Reclamation proposed a number of site-specific and programmatic components, which include three proposed implementation approaches: Core, Scheduling, and Collaborative Planning. "Core" actions are part of the Core Water Operations of the CVP and SWP. With "Scheduling" actions, agencies and water users provide recommendations to Reclamation on scheduling and shaping specific flow actions. With "Collaborative Planning" actions, agencies and water users work collaboratively to define, plan, and implement an action. Each component is organized according to watershed or river basin, but implemented in concert to achieve the comprehensive project goals. The PA consisted of the following components, which included a number of discrete action components over which Reclamation lacks discretionary authority or for which there is an existing biological opinion that covers the action. In subsequent sections, especially the effects of the action sections, NMFS describes the disposition of those PA components.

CVP/SWP-Wide:

- Divert and store water consistent with obligations under water rights and decisions by the State Water Resources Control Board
- Shasta Critical Determinations and Allocations to Water Service and Water Repayment Contractors

Upper Sacramento:

- Seasonal Operations
- Spring Pulse Flows
- Shasta Cold Water Pool Management
- Fall and Winter Refill and Redd Maintenance

- Operation of a Shasta Dam Raise
- Rice Decomposition Smoothing
- Spring Management of Spawning Locations
- Cold Water Management Tools (e.g., Battle Creek Restoration, Intake Lowering near Wilkins Slough Shasta TCD Improvements)
- Spawning and Rearing Habitat Restoration
- Small Screen Program
- Winter-run Conservation Hatchery Production
- Adult Rescue
- Juvenile Trap and Haul

Trinity/Clear Creek

- Seasonal Operations
- Whiskeytown Reservoir Operations
- o Clear Creek Minimum Flows
- Clear Creek Geomorphic and Spring Attraction Pulse Flows
- Spring Creek Debris Dam

American:

- Seasonal Operations
- 2017 Flow Management Standard Releases and "Planning Minimum"
- American River Pulse Flows
- Spawning and Rearing Habitat Restoration
- Drought Temperature Facility Improvements

Stanislaus River:

- Seasonal Operations
- Stanislaus River Stepped Release Plan
- Stanislaus River Pulse Flows
- o Alteration of Stanislaus DO Requirement
- Spawning and Rearing Habitat Restoration
- Temperature Management Study

San Joaquin

Lower San Joaquin River Habitat

Bay-Delta:

- Seasonal Operations
- Minimum Export Rate
- Delta Cross Channel Operations
- Agricultural Barriers
- Contra Costa Water District (CCWD) Rock Slough Operations
- North Bay Aqueduct (NBA)
- Water Transfers
- Clifton Court Aquatic Weed Removal
- Old and Middle River (OMR) Management

- o Tracy Fish Collection Facility Operations
- Skinner Fish Facility Operations
- Delta Smelt Habitat
- Clifton Court Predator Management
- San Joaquin Basin Steelhead Telemetry Study
- Sacramento Deepwater Ship Channel Food Study
- o North Delta Food Subsidies/Colusa Basin Drain Study
- Suisun Marsh Roaring River Distribution System Food Subsidies Study
- o Tidal Habitat Restoration (Complete 8,000 acres from 2008 biological opinion)
- Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
- Predator Hot Spot Removal
- Delta Cross Channel Gate Improvements
- Tracy Fish Facility Improvements
- Skinner Fish Facility Improvements
- Small Screen Program

During consultation, the Sacramento River Settlement Contractors drafted for vote A Resolution Regarding Salmon Recovery Projects in the Sacramento River Watershed, Actions Related to Shasta Reservoir Annual Operations, and Engagement in the Ongoing Collaborative Sacramento River Science Partnership Effort (Appendix A4). The Sacramento River Settlement Contractors, a California nonprofit mutual benefit corporation, consists of individuals and entities (collectively, SRS Contractors) that individually hold settlement agreements (the SRS Contracts) with the United States Bureau of Reclamation (Reclamation). The SRS Contractors consist of 31 members with an annual water supply of 1,974,324 acre feet. Reclamation operates Shasta Dam and Keswick Dam as part of the Central Valley Project and in accordance with the terms of the SRS Contracts.

The draft SRS Contractors resolution includes three key actions that are integrated into the description of the proposed action in this opinion:

- 1. The SRS Contractors intend to meet and confer with Reclamation, NMFS, and other appropriate agencies in connection with Reclamation's operational decision-making for Shasta Reservoir annual operations during drier water years with operational conditions as described in the Tier 3 and Tier 4 scenarios.
- 2. The SRS Contractors intend to continue to participate in, and act as project champions for, similar types of future Recovery Program projects, subject to the availability of funding, regulatory approvals, acceptable regulatory assurances.
- 3. The SRS Contractors are committed to continue their active engagement and leadership in the ongoing collaborative Sacramento River Science Partnership effort.

1.5.1 Interrelated or Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02 2007). There are no interdependent or interrelated activities associated with the proposed Federal action.

2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

2.1.1 Introduction

This section describes the analytical approach used by NMFS to evaluate the likely effects of the PA on listed species under NMFS jurisdiction and critical habitat designated for those species. The approach is intended to ensure that NMFS comports with the requirements of the statute and regulations when conducting and presenting the analysis. This includes using the best scientific and commercial data available in formulating the Opinion.

ESA section 7(a)(2) requires that the action agency "insure" that a PA "is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [designated critical] habitat...." This Opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02 2007). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This Opinion also relies on the regulatory definition of "destruction or adverse modification," which means "a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214 2016, 81 FR 7414 2016).

The designations of critical habitat for some of the listed fish included in this consultation use the term "primary constituent elements" (PCE) or "essential features." The revised critical habitat regulations (81 FR 7414 2016) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this Opinion, NMFS uses the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

NMFS uses the following approach to determine whether a PA is likely to jeopardize listed species or destroy, or adversely modify, critical habitat:

- Identify the range-wide status of the species and critical habitat likely to be adversely affected by the PA.
- Describe the environmental baseline in the action area as defined in the ESA implementing regulations (50 CFR 402.02).
- Analyze the effects of the PA on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors as follows: (1) review the status of the species and critical habitat; and (2) add the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the PA poses to species and critical habitat.
- Reach a conclusion about whether the PA is likely to jeopardize the continue existence of a listed species or result in the destruction or adverse modification of critical habitat.
- If necessary, suggest a reasonable and prudent alternative to the PA.

The subsections of Section 2.1 outline the specific conceptual framework, key steps, assumptions, and professional judgment NMFS used to assess the effects of the action on listed species and critical habitat. Wherever possible, these subsections apply to all five listed species and associated designated critical habitats occurring in the action area. The listed species and critical habitat include the following:

- Endangered Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU) (*Oncorhynchus tshawytscha*) and its designated critical habitat
- Threatened Central Valley (CV) spring-run Chinook salmon ESU (O. tshawytscha) and its designated critical habitat
- Threatened California Central Valley (CCV) steelhead distinct population segment (DPS) (O. mykiss) and its designated critical habitat
- Threatened sDPS of North American green sturgeon (*Acipenser medirostris*) and its designated critical habitat
- Endangered Southern Resident killer whale DPS (Orcinus orca).

The subsections of the analytical approach are as follows:

- Section 2.1.2 describes some aspects of the legal and policy framework provided by the ESA, implementing regulations, case law, and policy guidance related to section 7 consultations that informs and/or directs our analytical approach.
- Section 2.1.3 gives a general overview of how NMFS conducts its section 7 analysis. It includes various conceptual models of the overall approach and specific features of the approach. It also includes information on tools that NMFS used in the analysis specific to this consultation. The section first describes the listed species analysis as it pertains to individual fish species and the physical, chemical, and biotic changes to the ecosystem caused by the PA. It then describes the critical habitat analysis.
- Section 2.1.4 discusses the evidence available for the analysis and related uncertainties.
 We also describe the assumptions made using the best available data together with
 professional expertise and judgment to bridge data gaps, which contributes to the
 analyses.

- Section 2.1.5 diagrams the overall conceptual approach in the assessment to address integration of all available information and decision frameworks to support the assessment of the effects of the PA.
- Section 2.1.6 discusses the presentation of all analyses within this Opinion as a guide to locating results of specific analytical steps.

NMFS has evaluated the PA for this consultation as a "mixed programmatic" action as defined by 50 CFR 402.02 because it includes some action components for which no additional authorization will be necessary and others that are considered at a framework-level. Components that require no additional authorization are analyzed in this Opinion and exemptions from take prohibitions provided in the incidental take statement of this Opinion. Action components that are considered at a framework-level are also analyzed in this Opinion, but with a broader scale of examination of the components' potential impacts on listed species and critical habitat. Exemption from take prohibitions are not provided for these components in the incidental take statement of this Opinion. Once framework-level action components are further developed and provide sufficient detail for take determination, they will require additional ESA section 7 consultation before implementation; this subsequent consultation will include an incidental take statement for those components.

For components of the PA that lacked the specificity in description required to analyze a particular effect in detail, NMFS took a reasonably conservative approach to analyzing the range of effects that could result. This approach, paired with NMFS' identification of framework-level action components and the inclusion of additional analytical methods not used in the BA, could result in NMFS drawing different conclusions from our analysis than the action agency's conclusions in the biological assessment. We identify the lines of evidence to support NMFS' conclusions in the Effects Analyses and Integration and Synthesis sections of this Opinion.

2.1.2 Legal and Policy Framework

The ESA and its implementing regulations require NMFS to use the best scientific and commercial data available to complete formal consultations. However, NMFS is "not required to support its finding that a significant risk exists with anything approaching scientific certainty" San Luis & Delta-Mendota Water Auth. v. Jewell, 747 F.3d 581, 592 (9th Cir. 2014) (citations omitted). The final determination of whether or not the PA is likely to jeopardize the species' continued existence or destroy or adversely modify its critical habitat will be the product of a multi-layered analytical approach in which many of the intermediate results have associated degrees of uncertainty. When considering the uncertainty of the data, analytical methods, and results, NMFS takes into account the underlying purposes of Section 7 of the ESA and employs the precautionary principle where appropriate.

Consultations designed to allow Federal agencies to fulfill the requirements of section 7 of the ESA conclude with issuing a biological opinion or a concurrence letter. For biological opinions, section 7 of the ESA, implementing regulations (50 CFR 402.14), and associated guidance documents (USFWS and NMFS 1998 ESA Consultation Handbook) result in biological opinions to present the following:

- A description of the proposed Federal action
- A summary of the status of the affected species and its critical habitat

- A summary of the environmental baseline within the action area as defined in the ESA implementing regulations (50 CFR 402.02).
- A detailed analysis of the effects of the PA on the affected species and critical habitat
- A description of cumulative effects
- A conclusion as to whether it is reasonable to expect that the PA is not likely to
 appreciably reduce the species' likelihood of both surviving and recovering in the wild by
 reducing its reproduction, numbers, or distribution or result in the destruction or adverse
 modification of the species' designated critical habitat

The purpose of the jeopardy analysis is to determine whether appreciable reductions in the likelihood of both the survival and recovery of the species in the wild are reasonably expected, but not to precisely quantify the amount of those reductions. As a result, this assessment often focuses on whether an appreciable reduction is expected or not; it does not focus on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (absolute abundance, for example) that could occur as a result of PA implementation.

For Pacific salmon, steelhead, and certain other species, we commonly use four "viable salmonid population" (VSP) parameters (McElhany et al. 2000) to assess the viability of the populations that, together, constitute the species. When these parameters are collectively at an appropriate level, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. A designation of "a high risk of extinction" or "low likelihood of becoming viable" indicates that the species faces significant risks from internal and external processes that can drive it to extinction. The status assessment considers and diagnoses both internal and external processes affecting a species' extinction risk.

As identified in McElhany et al. (2000), the four VSP parameters for salmonids are important to consider because they are predictors of extinction risk. The parameters reflect general biological and ecological processes that are critical to the survival and recovery of the listed salmonid species (McElhany et al. 2000). The VSP parameters of productivity, abundance, and population spatial structure are consistent with the "reproduction, numbers, or distribution" referenced within the regulatory definition of "jeopardize the continued existence of" (50 CFR 402.02 2007) and are used as surrogates for "reproduction, numbers, or distribution." The VSP parameter of diversity relates to all three. For example, reproduction, numbers, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape levels. McElhany et al. (2000) highlight that the VSP framework will include "a degree of uncertainty in much of the relevant information," and that "because of this uncertainty, management applications of VSP should employ both a precautionary approach and adaptive management."

The PA does not include an explicit approach to adaptive management of the project components. While the February 5, 2019, version of the BA included project components that Reclamation labeled as "Adaptive Management" in Table 4-6, those items were relabled as "Scheduling" components in the revised proposed action posted by Reclamation on April 22, 2019. NMFS encourages the development of an adaptive management program to address uncertainties associated with the effectiveness of management actions taken to avoid jeopardy to federally listed species and destruction or adverse modification of critical habitat. A robust adaptive management component that would address the uncertainty identified by McElhany et

al. (2000) is expected to focus heavily on filling critical data and information gaps, enhancing the existing monitoring network, and improving quantitative modeling capability.

NMFS notes the regulatory definition of "jeopardize the continued existence of" includes the term "recovery" (50 CFR 402.02). NMFS finalized recovery plans for the listed Central Valley salmon and steelhead species in 2014 (National Marine Fisheries Service 2014b) and for the listed sDPS of green sturgeon in 2018 (National Marine Fisheries Service 2018g) These recovery plans, which include recovery objectives and criteria, also identify stressors or threats to the recovery of the species throughout their life cycles. This consultation uses the primary stressor and threat categories from the recovery plans as the basis for identification of potential stressors that could result from the proposed action and therefore could not only reduce appreciably the likelihood of survival of the species but also the likelihood of recovery of the species.

The information from recovery plans and the 2015/2016 Five-Year Status Reviews for each species represent the best scientific and commercial data available describing their respective current status, and were, therefore, incorporated into this Opinion. A technical recovery team (TRT) that assisted in the Central Valley salmonids recovery planning effort produced a "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin" (Lindley et al. 2007). Along with assessing the current viability of the listed Central Valley salmon and steelhead species, Lindley et al. (2007) made recommendations for recovering those species. The framework was used to inform the current status of the listed Central Valley salmon and steelhead species within this Opinion. The recovery plans, status reviews, and Lindley et al. (2007) were used as the foundation to determine whether the PA reasonably would be expected to "reduce appreciably the likelihood of both the survival and recovery of a listed species...". NMFS has also applied this framework in analyzing likely effects to recovering the sDPS of green sturgeon, a population represented by a single spawning population, much like the Sacramento River winter-run Chinook salmon population.

Additional requirements for the analysis of the effects of an action are described in regulations (50 CFR §402). The conclusions related to "jeopardize the continued existence of" and "destruction or adverse modification" require an expansive evaluation of direct and indirect consequences of the PA, interrelated and interdependent actions, and the overall context of the impacts to the species and habitat from past, present, and future actions as well as the condition of the affected species and critical habitat (for example, see the definitions of "cumulative effects" and "effects of the action" in 50 CFR §402.02 and the requirements of 50 CFR §402.14(g)).

Recent court cases have reinforced the requirements provided in the ESA section 7 implementing regulations that NMFS must evaluate the effects of a PA within the context of the current condition of the species and critical habitat, including other factors affecting the survival and recovery of the species and the functions and value of critical habitat for the conservation of the species. In addition, our risk assessments must consider the effects of climate change on the species and critical habitat and our analysis of the future impacts of a proposed action. NMFS acknowledges that the effects of climate change could have notable impacts on listed species while also recognizing the challenge in quantifying those effects. Conservation of protected resources becomes more difficult when considering a changing climate, especially when accounting for the relative uncertainty of the rate and magnitude of climate-related changes and

the response of organisms to those changes. Accordingly, NMFS issued general policy guidance for treatment of climate change in ESA decisions (Sobeck 2016). This guidance aligns with case law, noting the need to consider climate change in determinations and decisions despite the challenges of climate change uncertainty, and it provides policy considerations related to climate change that NMFS should use in ESA decision making, including ESA section 7 consultations.

In addition to Sobeck (2016), NMFS regional guidance (Thom 2016) further recommends use of the Representative Concentration Pathway (RCP) 8.5 scenario from the Fifth Assessment Report (AR5). Sobeck (2016) notes that "when data specific to (the RCP 8.5) pathway are not available, (NMFS) will use the best available science that is as consistent as possible with RCP 8.5." Climate change is incorporated into this analysis implicitly to an extent by the modeling results provided in the BA and additionally by qualitative evaluations that reflect more recent climate predictions applied in the Opinion. The modeling of the PA as provided in the biological assessment characterizes a 2030 scenario of climate conditions, water demands, and build-out. In doing so, the PA uses a multi-model ensemble-informed approach to identify a best estimate of the consensus of climate projections from the third phase of the Coupled Model Intercomparison Project (CMIP3), which informed the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4). These results are downscaled to a spatial resolution of approximately 12 km. This assessment report and approach results in an anticipated temperature change of +0.7 to +1.4 °C (representing the 25th to 75th quartile) and a precipitation change of -6 percent to +6 percent. Additionally, the approach used in for the PA characterizes 2030 sea level rise an 15 cm. However, based on results from the application of RCP 4.5 and RCP 8.5 in California's Fourth Climate Change Assessment (He et al. 2018, Pierce et al. 2018), NMFS expects that climate conditions will follow a more extreme trajectory of higher temperatures and shifted precipitation into 2030 and beyond. As provided by the assessment, NMFS assumes that temperatures would increase up to 1.9 °C between 2020-2059 and precipitation changes would range from -6 percent to +24 percent in the same period (He et al. 2018). Sea level rise is expected to range up to 15 cm in 2030 and 10-38 cm in 2050 (Pierce et al. 2018).

The October 29, 2018, Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West directed NMFS to complete this biological opinion within 135 days of receiving the biological assessment, and modeling for the proposed operations that uses data specific to RCP 8.5 is currently unavailable. Therefore this consultation assumes that the provided modeling represents a best-case scenario regarding climate conditions for 2030 and, to account for the differential in increased temperature, shifted precipitation, and projected sea level rise between the CMIP3 and California's Fourth Climate Change Assessment, NMFS will layer qualitative evaluations of increased climate effects onto the provided modeled data. This is consistent with guidance that "NMFS does not need to know with precision the magnitude of change over the relevant time period if the best available information allows NMFS to reasonably predict the directionality of climate change and overall extent of effects to species or its habitat" (Sobeck 2016)

Longer-term responses to climate uncertainty can be incorporated into a reinitiation trigger focused on regular assessments of adherence to the climate assumptions used in the analysis of this Opinion. To address shorter-term deviation from the current predictions, NMFS expects to be able to incorporate climate uncertainty into science plans by including monitoring of climate change effects and projections; taking management actions; and adjusting water operations, research, and monitoring in response as needed. Such responses may include, for instance,

identifying alternative locations for implementing restoration or habitat protection actions to increase habitat availability and suitability, increasing productivity of the food web, better managing predators and invasive species, or allowing species movement across environmental gradients. Adjustments to water operations associated with inflow, outflow, and exports are another example of potential responses to approaching reintiation triggers.

2.1.3 Overview of the Approach and Conceptual Models

NMFS uses a series of sequential activities and analyses to assess the effects of Federal actions on endangered and threatened species and designated critical habitat. These sequential activities and analyses are illustrated in

Figure 2.1.3-1 for listed species and Figure 2.1.3-2 for critical habitat. The final step in the series integrates the conclusions drawn from these activities, summarizing analyses in table format with consistent terms to facilitate the review of effects. In order for us to analyze the PA, it was first separated into components (deconstructed) for each division (as described in the BA). The first analysis uses the identified action components and interrelated and interdependent actions that resulted from the deconstruction of the action to identify environmental stressors. Specifically, the physical, chemical, or biotic aspects of the PA that are likely to have individual, interactive, or additive direct and indirect effects on the environment. As part of this step, NMFS identifies the spatial and temporal extent of both the action components and any potential stressors, recognizing that the spatial extent of the stressors may change with time. NMFS notes that the spatial extent of potential stressors may extend beyond the geographic area included in the project description (i.e., a project description of in-Delta operations may have effects that extend upstream; the spatial extent of those effects is traced as part of this analysis).

The next step in the series of analyses starts by identifying the threatened or endangered species or designated critical habitat that are likely to be exposed to (occur in the same space and at the same time as) the potential stressors and their spatial extent. We estimate the nature of co-occurrence of individuals and effect to represent the individual exposure assessment. In this step, we identify the proportion of a population (or number of individuals when available) and age (or life stage) that are likely to be exposed to an action's effects, and the specific areas and PBFs of critical habitat that are likely to be affected. We then assess the severity of an effect based on expected impact to the individual and its continued fitness or the expected impact to PBFs and value for conservation of critical habitat. Finally, we consider the incidence of exposure based on the activities in the description of the proposed action.

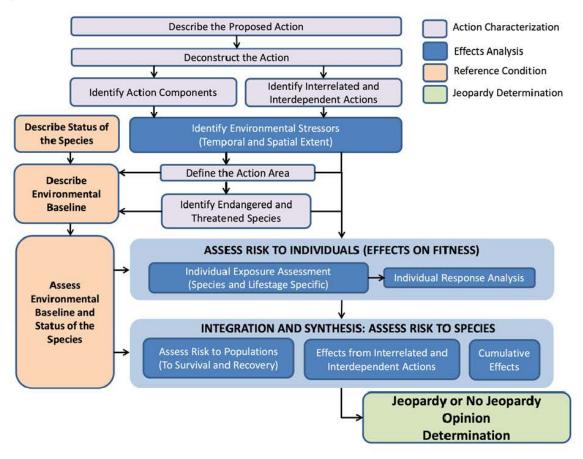


Figure 2.1.3-1. General Conceptual Model for Conducting Section 7 Analyses as Applied to Listed Species.

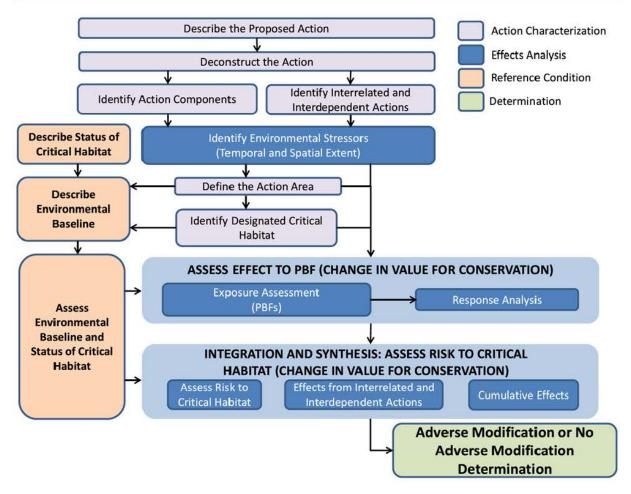


Figure 2.1.3-2. General Conceptual Model for Conducting Section 7 Analyses as Applied to Critical Habitat.

Once we identify which listed resources (i.e., endangered and threatened species and designated critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of the exposure, we examine the best scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure. This represents the individual response analysis. The final steps of our series of analyses establish the risks those responses pose to listed resources, with recognition that responses of individuals may differ within and between (subwatershed) populations and among species. These steps represent our risk analysis. They are different for listed species and designated critical habitat and are discussed in the following sections.

2.1.3.1 Application of the Approach to Listed Species Analyses

Our jeopardy determinations must be based on an action's effects on the likelihood of survival and recovery of threatened or endangered species as listed (e.g., as true biological species, subspecies, or distinct population segments of vertebrate species). Because the continued existence of listed species depends on the fate of the populations that comprise them, the

probability of extinction or probability of persistence of listed species depends on the probabilities of extinction and persistence of the populations that comprise the species. Similarly, the continued existence of a population is determined by the fate of the individuals that comprise it; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so). The approach for specific species are included below in Section 2.1.3.1.1 for salmonids and sturgeon and Section 2.1.3.1.2 for Southern Resident killer whale.

2.1.3.1.1 The Viable Salmonid Populations Framework Approach for Listed Salmonids and Southern Distinct Population Segment of Green Sturgeon

Although McElhany et al. (2000) specifically addresses viable populations of salmonids, NMFS believes that the concepts and viability parameters in McElhany et al. (2000) can also be applied to the Southern DPS of green sturgeon due to the general similarity in life cycle and freshwater/ocean use. Therefore, in this Opinion, NMFS applies McElhany et al. (2000) and the viability parameters in its characterization of the status of the species, environmental baseline, and analysis of effects of the action to the Southern DPS of green sturgeon.

Our analyses reflect these relationships. We identify the risks that actions pose to listed individuals that are likely to be exposed to effects of the actions. Our analyses then integrate the individuals' risks to identify consequences to the proportion of populations represented by the individuals (

Figure 2.1.3-1). Our analyses conclude by determining the consequences of those population-level risks to the species that the populations comprise.

To measure risks to listed individuals, we use changes in the individual's "fitness" as a metric. "Fitness" can be characterized as an individual's growth rate, survival probability, annual reproductive success, or lifetime reproductive success. In particular, during the individual response analysis, we examine the best scientific and commercial data available to determine if an individual's response to the effect of an action on the environment is likely to have consequences for the individual's fitness.

When individuals are expected to experience reduced fitness, we expect those reductions to also reduce the population abundance or rates of reproduction or growth rates (or to increase the variance in these rates) (Stearns 1992). Reduction in one or more of these variables is a necessary condition for decreases in a population's viability, which is a necessary condition for decreases in a species' viability.

If we conclude listed individuals are likely to experience reductions in their fitness, we evaluate whether those fitness reductions are likely to decrease the viability of the populations those individuals represent, or to reduce the likelihood of survival and recovery of those populations. This can be measured using changes in population abundance, reproduction rate, diversity, spatial structure and connectivity, growth rate, or variances in these metrics. In this step of our analysis, we use the population's baseline condition (established in the Status of the Species section of this Opinion) as our point of reference because the baseline condition is a measure of how close a species is to extinction.

An important tool in this step of the assessment is a consideration of the life cycle of the species. The consequences on a population's probability of extinction as a result of impacts to different

life stages are assessed within the framework of this life cycle and our current knowledge of the transition rates between life stages, the sensitivity of population growth to changes in those rates, and the uncertainty in the available estimates or information. An example of a Pacific salmonid life cycle is provided in Figure 2.1.3-3, which shows the cycle of the upstream freshwater spawning, juvenile smoltification and outmigration, ocean residence, and upstream spawning migration. Though not identical, the life history of green sturgeon is similar (i.e., spawning in upstream freshwater locations, juvenile outmigration through the riverine and estuarine areas, long ocean residence before returning to upstream spawning areas), and we take a similar approach in analyzing effects to both salmonids and sturgeon.

Various sets of data and modeling efforts are useful to consider when evaluating the transition rates between life stages and consequences on population growth as a result of variations in those rates. These data are not available for all species considered in this Opinion; however, data from surrogate species may be available for inference. Where available, information on transition rates, sensitivity of population growth rate to changes in these rates, and the relative importance of impacts to different life stages is used to inform the translation of individual effects to population-level effects.

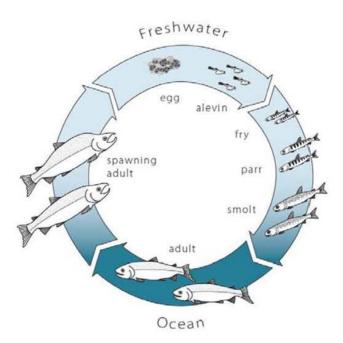


Figure 2.1.3-3. Conceptual Diagram of the Life Cycle of a Pacific Salmonid (NMFS 2016).

In addition, we recognize that populations may be vulnerable to small changes in life stage transition rates. Small reductions across multiple life stages can be sufficient to cause the extirpation of a population. This is illustrated in Figure 2.1.3-4 for two hypothetical scenarios with different transition rates (numbers included are for explanatory purposes only and do not reflect either observed or expected survival or production rates). For two adult salmon (a spawning pair) that produce 2,000 eggs that then experience a 20 percent survival rate to the juvenile stage, a 10 percent survival to smoltification, and a 5 percent survival over several years

at sea, two adult salmon will return to spawn again. However, if the survivorship is reduced to 18 percent at the juvenile stage, 8 percent at the smolt stage, and 4 percent at the sea stage, then only one adult salmon will return, leading to eventual extirpation if the trend continues.

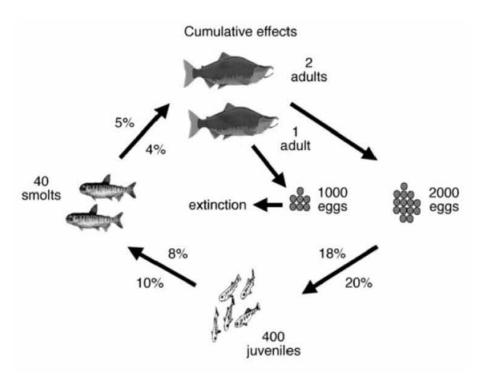


Figure 2.1.3-4. Illustration of Population Vulnerability to Small Changes in Transition Rates (Naiman and Turner 2000).

The section 7 consultation process requires assessment of the effects of several stressors to the species. The effects of these stressors require conceptual understanding of both the species' use of the area and the effects of the stressors on the species. NMFS closely considered the conceptual models of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) (Williams 2010) and the Salmon and Sturgeon Assessment of Indicators by Life stage (SAIL) (Heublein et al. 2017, Johnson et al. 2017, Windell et al. 2017) when identifying and evaluating the effects of activities associated with the PA. These models identify the effects of stressors such as increased temperature, toxins, changes in flow, minor and major diversions, the site of action, and the life stage affected. These stressors and their effects are reflected in the structure and evaluations of the effects analysis.

Our assessment next determines if changes in population viability are likely to be sufficient to reduce the viability of the species the population comprises. In this assessment, we use the species' status (established in the Status of the Species section of this Opinion) as our point of reference. We also use our knowledge of the population structure of the species (e.g., from the relevant recovery plan) to assess the consequences of the increase in extinction risk to one or more of those populations. Our Status of the Species section discusses the available information on the structure and diversity of the populations that comprise the listed species and any

available guidance on the role of those populations in the recovery of the species, noting that an action that is helping to implement recovery actions or strategies is less likely to jeopardize the continued existence of the species. We consider that recovery objectives and strategies are described in recovery plans and inform our analyses on likelihood of the proposed action to reduce appreciably the likelihood of species recovery. An example of structure and diversity information used in this assessment is provided in Figure 2.1.3-5 for CV spring-run Chinook salmon. This figure illustrates the historic distribution and structure of the species and notes those populations that have been extirpated. This information provides a sense of existing and lost diversity and structure within the species, which are important considerations when evaluating the recovery consequences of extinction risk or effects to current or potential habitat.



Figure 2.1.3-5. Current and Historical Distribution of the Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit.

Box 1: An example of the determination of effects to individuals of a species.

The first steps in evaluating the potential impacts a project may have on an individual fish would entail: (1) identifying the seasonal periodicity and life history traits and biological requirements of listed salmonids and sturgeon within the action area. Understanding the spatial and temporal occurrence of these fish is a key step in evaluating how they are affected by current human activities and natural phenomena; (2) identifying the main variables that define riverine or estuarine characteristics that may change as the result of project implementation; (3) determining the extent of change in each variable in terms of time, space, magnitude, duration, and frequency; (4) determining if individual listed species will be exposed to potential changes in these variables; (5) evaluating how the changed characteristic would affect the individual fish in terms of the fish's growth, survival, and/or reproductive success; (6) and determining the proportion of a population affected.

As an example, riverine characteristics may include flow, water quality, vegetation, channel morphology, hydrology, neighboring channel hydrodynamics, and connectivity among upstream and downstream processes. Each of these main habitat characteristics is defined by several attributes (e.g., water quality includes water temperature, dissolved oxygen, ammonia concentrations, turbidity). The degree to which the proposed project may change attributes of each habitat characteristic will be evaluated quantitatively and/or qualitatively in the context of its spatial and temporal relevance. Not all of the riverine characteristics and associated attributes identified above may be affected by project implementation to a degree where meaningful qualitative or quantitative evaluations can be conducted. That is, if differences in flow with and without the proposed project implementation are not sufficient to influence neighboring channel hydrodynamics, then these hydrodynamics will not be evaluated in detail either quantitatively or qualitatively. The changed nature of each attribute will then be compared to the attribute's known or estimated habitat requirements for each fish species and life stage. For example, if water temperature modeling results demonstrate that water temperatures during the winter-run Chinook salmon spawning season (mid-April through mid-August) would be warmer with implementation of the proposed project, then the extent of warming and associated impact would be assessed in consideration of the water temperature ranges required for successful winter-run Chinook salmon spawning.

NMFS will then evaluate how the proposed project's effects on riverine characteristics may affect the growth, survival, and reproductive success of individual fish. For example, all of these metrics may be affected if the proposed project results in increased water temperatures during multiple life stages. Individual fish growth also may be affected by reduced availability, quantity, and quality of habitats (e.g., floodplains, channel margins, intertidal marshes). Survival of an individual fish may be affected by suboptimal water quality, increased predation risk associated with non-native predatory habitats and physical structures, impeded passage, and susceptibility to disease. Reproductive success of individual fish may be affected by impeded or delayed passage to natal streams; suboptimal water quality (e.g., temperature), which can increase susceptibility to disease; and reduced quantity and quality of spawning habitats. Instream flow studies (e.g., instream flow incremental methodology studies) available in the literature, which describe the relationship between spawning habitat availability and flow, will be used to assess proposed project-related effects on reproductive success. All factors associated with the proposed project that affect individual fish growth, survival, or reproductive success will be identified during the exposure analyses.

We use a set of tables to collect and evaluate the available information on the expected effects of each component action of the PA. These tables identify the stressor effect mechanism and the exposure, response, and risk posed to individuals and proportion of the species.

Table 2.1.3-1 outlines the basic set of information we evaluated, and Box 1 offers an example of the conceptual thought behind the information in the table. We categorize the effects to individuals on the basis of the severity of the predicted response and resulting fitness consequence within life stages.

Table 2.1.3-1. Example of Information Used to Identify Effects of the Components of the Proposed Action to Listed Species.

		Life Stage Individual		Proportion					
		Timing (Work	Response and	Severity	of	Frequency			Expected
	Life Stage	Window	Rationale of	of	Population	of	Magnitude	Weight of	Change in
Stressor	(Location)	Intersection)	Effect	Stressor	Exposed	Exposure	of Effect	Evidence	Fitness

As Table 2.1.3-1 shows, for each response to an action, we assign a relative magnitude of effect (high, medium, or low). This is a qualitative assessment of the likelihood of a fitness consequence occurring that allows for incorporation of some aspects of uncertainty (for instance, an infrequent but documented presence of a small number of individuals at a particular time). It is based on assessment of the severity or level of benefit of the stressor, the proportion of the population exposed, and the frequency of exposure. Severity is categorized as lethal, sublethal, or minor; level of benefit categories are high, medium, and low. High benefit addresses one or more lethal stressors such that individual survival is expected to increase. Medium benefit addresses one or more sub-lethal stressors such that individuals are expected to experience some increase in condition, but no change in survival is expected. Low benefit addresses one or more minor stressors, but it is not obvious that individuals would gain in condition. The proportion of the population exposed (for the fish species) is characterized similarly as in NMFS (2009) as large (70 percent or more exposed), medium (more than 2 percent, but less than 70 percent exposed), and small (exposure not expected to exceed 2 percent). We note that this includes intra-annual exposure (i.e., exposure of the same cohort to a stressor multiple times in a year). The frequency of exposure is categorized as high (very frequent; occurring in 75 percent or more years), medium (moderately frequent; occurring in 25-75 percent of years), and low (infrequent; occurring in fewer than 25 percent of years). Table 2.1.3-2 shows combinations of severity, proportion, and frequency that result in the various magnitudes of effect.

Table 2.1.3-2 Categories of Effect Magnitude

A - Severity of Stressor (Lethal/ Sublethal/ Minor); Or Level of Individual Benefit for Conservation Measures (High/Medium/Low)	B - Proportion of Population Exposed (Large/ Medium/ Small)	C - Frequency of Exposure (High/ Medium/ Low)	Resulting Magnitude of Effect – Combination of A, B, and C
Lethal Stressor; High	Large or Medium	High, Medium, or Low	High
Sublethal; Medium	Large	High	High
Lethal; High	Small	High or Medium	Medium
Sublethal; Medium	Large	Medium or Low	Medium

A - Severity of Stressor (Lethal/ Sublethal/ Minor); Or Level of Individual Benefit for Conservation Measures (High/Medium/Low)	B - Proportion of Population Exposed (Large/ Medium/ Small)	C - Frequency of Exposure (High/ Medium/ Low)	Resulting Magnitude of Effect - Combination of A, B, and C
Sublethal; Medium	Medium	High or Medium	Medium
Sublethal; Medium	Small	High	Medium
Minor; Low	Large	High or Medium	Medium
Minor; Low	Medium	High	Medium
Lethal Stressor; High	Small	Low	Low
Sublethal; Medium	Medium	Low	Low
Sublethal; Medium	Small	Medium or Low	Low
Minor; Low	Small	Low	Low
Minor; Low	Medium or Small	Medium or Low	Low
Minor; Low	Small	High, Medium, or Low	Low

The weight of evidence for stressor effect identified in Table 2.1.3-2 is based on the best available scientific information and is categorized based on the characteristics of the analytical method, with modifications to include statistical power of analytical methods. Weights are defined as follows:

- High: Supported by multiple scientific and technical publications, especially if conducted on the species within the area of effect, quantitative data, and/or modeled results; high power in interpretation of analytical results
- Medium: Evidence between high and low definitions
- Low: One study, or unpublished data, or scientific hypotheses that have been articulated but not tested; low power in interpretation of analytical results

A key consideration in this assessment is the strategy of the NMFS recovery plan that "every extant population be viewed as necessary for the recovery of the ESUs and DPS," and that "wherever possible, the status of extant populations should be improved" (National Marine Fisheries Service 2014b). Noted recovery actions include (but are not limited to) reintroduction

of populations into key watersheds, completion of landscape-scale restoration throughout the Delta, restoring flows throughout the Sacramento and San Joaquin river basins and the Delta, reducing the biological impacts of exporting water through the CVP and SWP facilities, and meeting established water quality criteria. Several of these recovery actions could be affected by the PA and, therefore, could contribute to either recovery or jeopardy. NMFS considers that an expected appreciable reduction in any population's viability due to implementation of the PA could also appreciably reduce the likelihood of survival and recovery of the population's diversity group and the ESU/DPS. Therefore, this assumption in our analysis of effects is consistent with the principle of institutionalized caution.

There are, however, other considerations, including the timing, duration, and magnitude of the reduction and the permanent or temporary nature of the reduction. A PA could, therefore, adversely affect a population without appreciably reducing the likelihood of survival of the species.

Table 2.1.3-3 presents the basic set of outcomes associated with acceptance or rejection of the propositions used when evaluating effects of the PA. These follow a logical path and hierarchical structure that is used to organize the jeopardy risk assessment. This table is populated using results from Table 2.1.3-1 as completed for all stressors. For each step in Table 2.1.3-3, the stressor result that supports the true or false determination will be identified, with documentation of the magnitude of effect and weight of evidence, to allow clear disclosure of potential for uncertainty. While the approach cannot remove the uncertainty, it can allow a determination to be made based on a methodological approach of the magnitude of effect and weight of evidence.

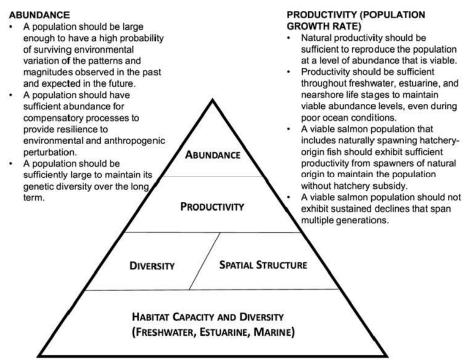
Table 2.1.3-3. Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on Listed Species.

Step	Apply the Available Evidence to Determine if	True/False	Action
	The proposed action is not likely to produce stressors that have direct or	True	End
Α	indirect adverse effects on the environment	False	Go to B
В	Listed individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the	True	NLAA
В	proposed action	False	Go to C
С	Listed individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action	True	NLAA
C		False	Go to D
D	Any responses are not likely to constitute "take" or reduce the fitness of the	True	NLAA
D	individuals that have been exposed	False	Go to E
Е	Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent	True	NLJ
E		False	Go to F
F	Any reductions in the viability of the exposed populations are not likely to	True	NLJ
Г	reduce the viability of the species	False	LJ

Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and not likely/likely to jeopardize (NLJ/LJ).

In order to assess the survival and recovery of any species, a guiding framework that includes the most appropriate biological and demographic parameters is required. This has been generally defined above. For Pacific salmonids, McElhany et al. (2000) defines a VSP as an independent population that has a negligible probability of extinction over a 100-year timeframe. The VSP concept provides specific guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as at the ESU or DPS level.

Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (i.e., population growth rate); (3) population spatial structure; and (4) diversity (McElhany et al. 2000). These four parameters and their associated attributes are presented in Figure 2.1.3-6.



DIVERSITY

- Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity (birth rate), morphology, behavior, and genetic characteristics.
- The rate of gene flow among populations should not be altered by human-caused factors.
- Natural processes that cause ecological variation should be maintained.

SPATIAL STRUCTURE

- Habitat patches should not be destroyed faster than they are naturally created.
- Human activities should not increase or decrease natural rates of straying among salmon sub-populations.
- Habitat patches should be close enough to allow the appropriate exchange of spawners and the expansion of population into underused patches.
- Some habitat patches may operate as highly productive sources for population production and should be maintained
- Due to the time lag between the appearance of empty habitat and its colonization by fish, some habitat patches should be maintained that appear to be suitable, or marginally suitable, even if they currently contain no fish.

Figure 2.1.3-6. Viable Salmonid Population Parameters and Their Attributes (from McElhany et al. 2000).

In addition to the four key parameters, the quality, quantity, and diversity of the habitat (habitat capacity and diversity) available to the species in each of its three main habitat types (freshwater, estuarine, and marine environments) is a foundation to VSP. Salmonids cannot persist in the wild and withstand natural environmental variations in limited or degraded habitats. Therefore, the condition and capacity of the ecosystem upon which the population (and species) depends play a critical role in the viability of the population or species. Without sufficient space, including accessible and diverse areas the species can utilize to weather variation in their environment, the population and species cannot be resilient to chance environmental variations and localized catastrophes. Salmonids have evolved a wide variety of life history strategies designed to take advantage of varying environmental conditions. Loss or impairment of the species' ability to use these adaptations increases their risk of extinction.

Recent research shows that a diversity of life histories among populations contributes to the maintenance of multiple and diverse salmonid stocks fluctuating independently of each other, which in turn reduces species extinction risk and long-term variation in regional abundances (Hilborn et al. 2003, Schindler et al. 2010, Yates et al. 2012, Satterthwaite and Carlson 2015). Such variance buffering of complex ecological systems has been described as a portfolio effect (Schindler et al. 2010), borrowing on concepts from financial portfolio theory (Markowitz 1952, Koellner and Schmitz 2006, Satterthwaite and Carlson 2015).

California's Central Valley salmon portfolio has weakened over time (Carlson et al. 2011, Herbold et al. 2018). The foundation for this "portfolio effect" of spreading risk across populations can be found at the within-population scale (Greene 2009, Bolnick et al. 2011). For example, juvenile Chinook salmon leave their natal rivers at different sizes, ages, and times of the year, and this life history variation is believed to contribute to population resilience (Beechie et al. 2006, Lindley et al. 2009, Miller et al. 2010, Satterthwaite et al. 2014, Sturrock et al. 2015). Life history diversity promotes salmonid population resiliency, thereby reducing a species' extinction risk. Thus, preserving and restoring life history diversity is an integral goal of many salmonid conservation programs (Ruckelshaus et al. 2002). It is increasingly recognized that strengthening a salmon population's resilience to environmental variability (including climate change) will require expanding habitat opportunities to allow a population to express and maintain its full suite of life history strategies (Bottom et al. 2011, Herbold et al. 2018, Munsch et al. 2019).

As presented in National Marine Fisheries Service (2014b), criteria for VSP are based upon measures of the VSP parameters that reasonably predict extinction risk and reflect processes important to populations. Abundance is critical because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (i.e., population growth rate) provides information on important demographic processes. Genotypic and phenotypic diversity are important because they allow species to use a wide array of environments, respond to short-term changes in the environment, and adapt to long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats and can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. However, each of these parameters, and the criteria that can be developed from them, must be sensitive to the uncertainty of estimates, levels, and processes (McElhany et al. 2000).

The VSP concept also identifies guidelines describing a viable ESU/DPS. The viability of an ESU or DPS depends on the number of populations within the ESU or DPS, their individual status, their spatial arrangement with respect to each other and to sources of potential catastrophes, and diversity of the populations and their habitat (Lindley et al. 2007). Guidelines describing what constitutes a viable ESU are presented in detail in McElhany et al. (2000). More specific recommendations of the characteristics describing a viable Central Valley salmonid population are found in Table 1 of Lindley et al. (2007). The effects of the PA are analyzed with consideration for the diversity and spatial structure of the salmonid populations. Because the effects of the PA are experienced at locations where individual populations (e.g., Mill Creek spring-run Chinook salmon and Butte Creek spring-run Chinook salmon) come together, the effects to individual populations are not always differentiated in the effects analysis. In order to assess the likelihood of survival and recovery of spring-run Chinook salmon, all Sacramento River basin populations are analyzed as a single unit. Effects are separately analyzed for San Joaquin River basin spring-run Chinook salmon. The San Joaquin River basin includes both Chinook salmon with run timing typical of juvenile and adult spring-run Chinook salmon ("spring-running" Chinook salmon), and the reintroduced spring-run Chinook salmon when outside of the experimental population designation area. This experimental population is exempt from ESA section 9 take prohibitions when inside the designation area, but, does not carry take exemptions when outside of the designated area, or in an area of overlap with individuals that are not part of the experimental population (50 CFR 222.501(a)). Steelhead populations are similarly analyzed in the effects analysis based on basin of origin. However, the impacts to the diversity and spatial structure provided by the individual populations will be evaluated when the VSP approach is applied in the integration and synthesis for the ESU/DPS.

We nest the VSP concept within the hierarchy of the individual-population-diversity group-ESU/DPS relationships to evaluate the potential impact of the PA. For the species, the conceptual model is based on a bottom-up hierarchical organization of individual fish at the life stage scale, population, diversity group (if applicable), and ESU/DPS (Figure 2.1.3-7). The viability of a species (e.g., ESU) is dependent on the viability of the population(s) or diversity groups that compose that species and the spatial distribution of those groups or populations; the viability of a diversity group is dependent on the viability of the population(s) that compose that group and the spatial distribution of those population(s); and the viability of the population is dependent on the four VSP parameters and on the fitness and survival of individuals at the life stage scale. The anadromous salmonid life cycle (see Figure 2.1.3-3) includes the following life stages and behaviors, which are evaluated for potential effects resulting from the PA:

- Adult immigration and holding
- Spawning, embryo incubation
- Juvenile rearing and downstream movement¹
- Smolt outmigration

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¹ The juvenile rearing and downstream movement life stage is intended to include fry emergence and fry and fingerling rearing, which occurs both in natal streams and as these fish are moving downstream through migratory corridors at a pre-smolt stage. The distinction between juveniles and smolts is made because smolts have colder thermal requirements than juveniles that are not undergoing osmoregulatory physiological transformations.

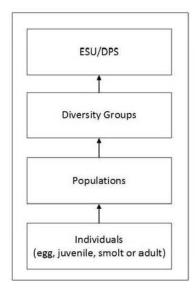


Figure 2.1.3-7. Conceptual Model of the Hierarchical Structure that is Used to Organize the Jeopardy Risk Assessment for Anadromous Salmonids.

2.1.3.1.2 Approach Specific to Southern Resident Killer Whales

The Overview of the Approach and Models Used (Section 2.1.3) and Application of the Approach to Listed Species Analysis (Section 2.1.3.1) described above also apply to NMFS' approach for Southern Resident killer whales (Southern Residents). As appropriate, we use NMFS WCR Guidance (National Marine Fisheries Service 2013a) on how to identify key components and characterize the potential effects of the PA on Southern Residents in this consultation. The Southern Resident DPS is a single population. The population is composed of three pods, or groups of related matrilines, that belong to one clan of a common but older maternal heritage (National Marine Fisheries Service 2008a). The Southern Resident population is sufficiently small that the relative fitness of all individuals from each pod can influence the survival and recovery of the DPS. Southern Residents are known to prefer Chinook salmon as their primary prey (Ford and Ellis 2006, Hanson et al. 2010), and Southern Resident population dynamics have previously been correlated with the abundance of Chinook populations over a broad scale throughout their range (Ward et al. 2013) Prior sections have discussed the analytical approach to assessing impacts to ESA-listed Chinook salmon. Similarly, an accompanying analysis of impacts to non-ESA-listed Chinook salmon will be performed to support assessment of effects on Southern Resident killer whale prey base. This analysis of effects to Southern Residents relies on the expected impacts of the PA on the abundance and availability of Chinook salmon for prey and how any expected changes in prey availability will affect the fitness, and ultimately the abundance, reproduction, and distribution, of the Southern Resident DPS.

2.1.3.2 Application of the Approach to Critical Habitat Analyses

The basis of the destruction or adverse modification analysis is to evaluate whether the PA affects the quantity or quality of the PBFs in the designated critical habitat for a listed species and, especially in the case of unoccupied habitat, whether the PA has any impacts to the critical

habitat itself. Specifically, NMFS will conclude that a PA is likely to destroy or adversely modify the designated critical habitat for the ESU/DPS if the action results in a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (50 CFR 402.02). NMFS bases critical habitat analysis on the affected areas and functions of critical habitat essential for the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the PA on the natural environment, NMFS asks if PBFs included in the designation that give the designated critical habitat value for the conservation of the species are likely to respond to that exposure. In particular, NMFS is concerned about responses that are sufficient to reduce the quantity or quality of those PBFs or capacity of that habitat to develop those features over time.

The analysis of effects on critical habitat is based on the species effects analysis and is summarized as they relate to the PBFs of critical habitat. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure and condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure-response-risk) as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles are likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

To conduct this analysis, NMFS follows the basic exposure-response-risk analytical steps described in Figure 2.1.3-2 and applies a set of reasoning and decision-making questions designed to aid in this determination. These questions follow a similar logic path and hierarchical approach to the elements and areas within a critical habitat designation. Table 2.1.3-4 outlines the reasoning and decision-making steps in the determination of effects of the PA on designated critical habitat. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Table 2.1.3-5 includes the collection of information used to evaluate the effects of components of the PA on critical habitat.

Table 2.1.3-4. Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on Designated Critical Habitat.

Step	Apply the Available Evidence to Determine if	True/False	Action	
A	The proposed action is not likely to produce stressors that have direct or	True	End	
	indirect adverse effects on the environment	False	Go to B	
В	Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect effects of	True	NLAA	
	the proposed action	False	Go to C	
С	The quantity or quality of any physical or biological features of critical habitat or capacity of that habitat to develop those features over time are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action	True	NLAA	
		False	Go to D	
D	Any reductions in the quantity or quality of one or more physical or iological features of critical habitat or capacity of that habitat to develop	True	NLAA	
	those features over time are not likely to reduce the value of critical habitat for the conservation of the species in the exposed area	False	lse Go to E	
Е	Any reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are not likely to appreciably	True	No D/AD MOD	
E	diminish the overall value of critical habitat for the conservation of the species	False	D/AD MOD	

Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Table 2.1.3-5. Example of Information Used to Identify Effects of the Components of the Proposed Action to Critical Habitat.

Action Component	Location of Effect	Physical and Biological Features Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Expected Change in PBF Supporting the Life History Needs of
		reatures Affected	Effect			the Species

Table 2.1.3-3 and Table 2.1.3-4 allow us to determine the expected consequences of the action on PBFs, sort or rank the magnitude of those consequences, and determine whether areas of critical habitat are exposed to additive effects of the PA and the environmental baseline. We recognize that the value of critical habitat for the conservation of the species is a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, changes in the dynamics of biotic components of the habitat, etc. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also consider how the physical and biological features of designated critical habitat are likely to respond to any interactions with and synergisms between cumulative effects of pre-existing stressors and proposed stressors.

At the heart of the analysis is the basic premise that the value of an overall critical habitat designation for the conservation of the species is the sum of the values of the components that comprise the habitat. For example, the value of listed salmonid critical habitat for the conservation of the species is determined by the value of the watersheds or other areas that make

up the designated area. In turn, the value of the watersheds or other areas is based on the quantity or quality of PBFs of critical habitat or capacity of that habitat to develop those features over time in that area. Some areas that are currently in a degraded condition may have been designated as critical habitat for their potential to develop or improve and eventually provide the needed ecological functions to support species' recovery. Under these circumstances, NMFS may conclude that an action is likely to "destroy or adversely modify" the designated critical habitat if the action alters it or prevents it from improving over time relative to its pre-action condition.

Therefore, reductions in the quantity or quality of any PBFs of critical habitat or capacity of that habitat to develop those features over time may reduce the value of the exposed area (e.g., watersheds) for the conservation of the species, which in turn may reduce the value of the overall critical habitat designation for the conservation of the species.

There are, however, other considerations. We look to various factors to determine if the reduction in the quantity or quality of any PBFs of critical habitat or capacity of that habitat to develop those features over time would affect the value of the critical habitat for the conservation of the species. Examples of these factors include the following:

- The timing, duration, and magnitude of the reduction
- The permanent or temporary nature of the reduction

We use the current value for the conservation of the species of those areas of designated critical habitat that occur in the action area as our point of reference for our assessment of effects of the PA on designated critical habitat. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species, then that limited value is our point of reference for our assessment of the consequences of the effects of the PA on the value of the overall critical habitat designation for the conservation of the species. In addition, we must determine whether reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are likely to appreciably diminish the overall value of critical habitat for the conservation of the species. A PA could adversely affect critical habitat in an action area without appreciably diminishing the value of critical habitat for the conservation of the species.

2.1.3.3 Characterization of the Environmental Baseline

ESA regulations define the environmental baseline as "the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR 402.02 2007). The environmental baseline provides a description of the conditions during the time period associated with the effects of the proposed action. The "effects of the action" include the direct and indirect effects of the PA and of interrelated or interdependent actions "that will be added to the environmental baseline" in the integration and synthesis, which is the subsequent section of an opinion (50 CFR 402.02 2007).

In the Environmental Baseline section (Section 2.4), we summarize the past and present impacts leading to the current status of the species in the action area, including the effects of CVP and

SWP operations to date. The Environmental Baseline section also describes the exposure to non-project stressors that are expected to occur in the future (e.g., climate change), or extend into the future, affecting listed species and their critical habitats. Therefore, as illustrated in

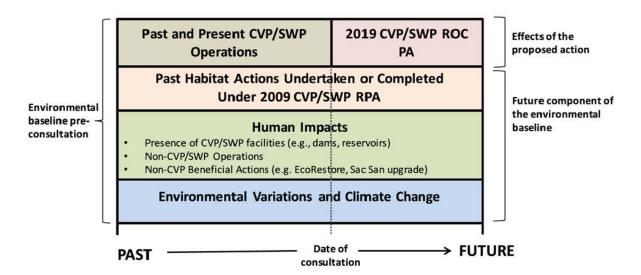


Figure 2.1.3-8, the pre-consultation environmental baseline characterizes the effects of the combination of natural environmental variation, human impacts, including those associated with past and current operations of the CVP and SWP, and past habitat actions undertaken or completed under the 2008 USFWS and 2009 NMFS Opinions on the CVP and SWP operations. Note that the figure blocks are illustrative of general regulatory categories of effects that will be aggregated in the analysis. The figure does not denote relative intensity of effect or whether impacts are positive or negative; temporal variability of effect/impact is not depicted.

Implicit in both these definitions of environmental baseline and effects of the action is a need to anticipate future effects, including the future component of the environmental baseline. Future effects of Federal projects that have undergone consultation and of contemporaneous State and private actions, as well as future changes due to environmental variations, are future components of the environmental baseline, to which effects of the proposed project are added in the integration and synthesis section. In accordance with NMFS guidance (Sobeck 2016), climate change is included along with environmental variations in order to best characterize the future condition that the species will encounter.

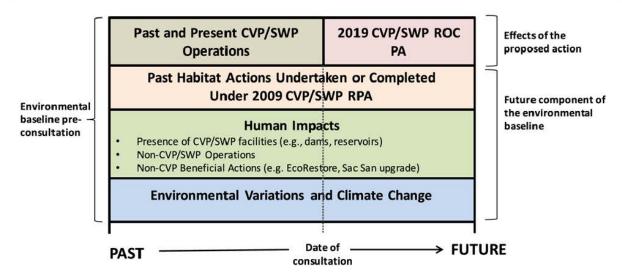


Figure 2.1.3-8. A Conceptual Model of the Effects of the Proposed Action Added on Top of the Future Component of the Environmental Baseline. Figure blocks are illustrative of general categories of components. Figure does not denote relative intensity of effect or whether impacts are positive or negative; temporal variability of effect/impact is not depicted.

To consider the effects of the action in the context of environmental baseline conditions, the analysis considers future effects of Federal projects that have undergone consultation and of contemporaneous State and private actions, as well as future changes due to natural processes, along with the effects of the proposed project. Given the timeline of the PA and because it includes an ongoing action (i.e., ongoing delivery of water), we analyze the entire suite of project effects along with environmental baseline conditions in the future, which captures anticipated effects of non-project processes and activities. As presented in the BA, the PA includes operations of the CVP and SWP in the future. Therefore,

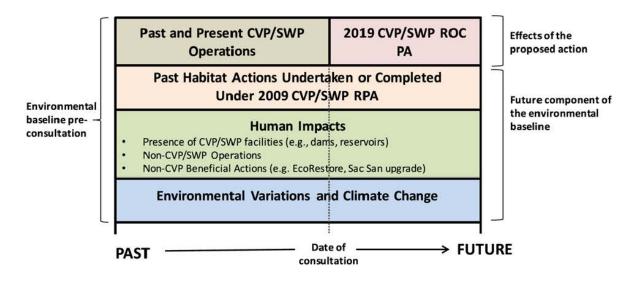


Figure 2.1.3-8 illustrates that the integrated analysis will include the effects to listed species and critical habitat from past actions governed by components of the 2009 NMFS Opinion along with effects of the PA.

2.1.4 Evidence Available for the Analysis

The primary source of initial project-related information was the biological assessment for the ROC on LTO of the CVP and SWP, multi-agency meetings with the action agency to discuss project details and clarifications, and supplemental notes and data files provided through April of 2019. However, to conduct the consultation analyses, NMFS considered current literature and published information to provide a foundation for the analysis and represent evidence or absence of adverse consequences. In addition to a thorough review of up-to-date literature and publications reflected in the references cited in individual sections, the following provides a list of resources that we considered in the development of our analyses:

- Final rules listing the species in this Opinion as threatened or endangered
- Final rules designating critical habitat for the CV salmon and steelhead species and sDPS of green sturgeon
- Final rule describing the use of surrogates in ITSs (80 FR 26832 2015)
- Final rule defining destruction or adverse modification of critical habitat (81 FR 7214 2016)
- Final rule defining physical and biological features as replacements for primary constituent elements (81 FR 7414 2016)
- 2016 5-year Status Review: Summary and Evaluation of Sacramento River Winter-run Chinook Salmon ESU
- 2016 5-year Status Review: Summary and Evaluation of CV Spring-run Chinook Salmon ESU
- 2016 5-year Status Review: Summary and Evaluation of CCV Steelhead DPS
- 2015 5-year Status Review: Summary and Evaluation of sDPS Green Sturgeon
- 2016 5-year Status Review: Summary and Evaluation of Southern Resident Killer Whale
- NMFS 2009 biological opinion on CVP and SWP operations and 2011 amendments to the reasonable and prudent alternative
- 2014 NMFS Recovery Plan for CV salmonids
- 2018 NMFS Recovery Plan for sDPS of green sturgeon
- 2008 NMFS Recovery Plan for Southern Resident killer whale
- Past independent reviews (i.e., CVP and SWP biological opinions, CVP/SWP operations biological opinion annual reviews)
- Information included in Collaborative Science and Adaptive Management Program processes
- NMFS Selected Science Review for the Reinitiation Effort (Byrne 2018)

2.1.4.1 Primary Analytical Models

The ROC on LTO BA includes a suite of models used in the analysis of the effects of the operations of the PA. NMFS used these model results along with results from additional

analytical methods listed below, with an asterisk (*) denoting models specific to the Opinion. The models specific to the Opinion were not included in the BA submission but were provided to NMFS by Reclamation at NMFS' request. NMFS did not develop new scenarios for analysis; that is, the BA included modeling of two scenarios (a proposed action and a current operations scenario), and NMFS analyzed the results of these scenarios. Not all tools were used in all divisions, as some are only applicable to certain rivers or geographic areas. Fundamental models used in the Opinion include the following:

- CalSimII: A hydrological planning scenario tool that provides monthly average flows for the entire SWP and CVP system based on an 82-year record (1922-2003).
- DSM2-HYDRO: One-dimensional hydraulic model used to predict flow rate, stage, and water velocity in the Delta and Suisun Marsh and used to support routing and hydrodynamic analyses.
- HEC-5Q: Uses CalSimII flow and climatic model output to predict monthly water temperature on the Trinity, Feather, American, and Stanislaus River basins and upstream reservoirs.
- Reclamation Egg Mortality Model*/SacSalMort*: Temperature-exposure mortality
 criteria for three life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) are
 used along with the spawning distribution data and output from the river temperature
 models to compute percentage of salmon spawning losses; used in fall-run and late fallrun Chinook salmon analysis in evaluation of SRKW prey base.
- SALMOD*: Predicts effects of flows on habitat suitability and quantity for all races of Chinook salmon in the Sacramento River.
- DPM*: Simulates migration and mortality of Chinook salmon smolts entering the Delta from the Sacramento, Mokelumne, and San Joaquin rivers through a simplified Delta channel network, and provides quantitative estimates of relative Chinook salmon smolt survival through the Delta to Chipps Island.
- IOS*: A stochastic life cycle model for winter-run Chinook salmon the Sacramento River.
- Salvage-Density Analysis*: A model of entrainment into the south Delta facilities as a function of flow based on historical salvage data.
- NMFS-Southwest Fisheries Science Center Temperature Dependent Egg Mortality Model (Martin et al. 2017): A temperature-dependent mortality model for Chinook salmon embryos that accounts for the effect of flow and dissolved oxygen on the thermal tolerance of developing eggs.
- Sacramento River Winter-run Chinook Salmon Life Cycle Model*: A state-space and spatially explicit life cycle model of eggs, fry, smolts, juveniles in the ocean, and mature adults that includes density-dependent movement among habitats.
- Anderson Egg Mortality Model: Models for managing the Sacramento River temperature during the incubation of winter-run Chinook salmon which characterize temperature-and density-dependent mortality from egg through fry survival.
- Weighted Usable Area*: A computation of the surface area of physical habitat available weighted by its suitability according to studies assessing suitability of physical and (at times) chemical factors such as substrate particle size, water depth, flow velocity, and dissolved oxygen.

- Floodplain Inundation*: Analysis of flow results to determine suitable area based on floodplain hydraulic modeling studies that informed relationships between floodplain flow and suitable area.
- STARS Model (Perry et al. 2019): Survival, Travel Time, and Routing Simulation model developed by USGS. A stochastic, individual based simulation model designed to predict survival of a cohort of a fish that experiences variable daily river flows as they migrate through the Delta.

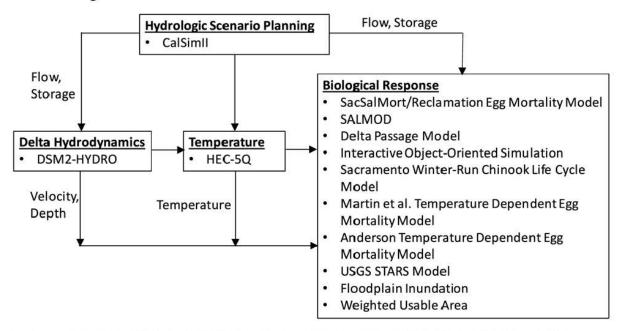


Figure 2.1.4-1. Main Models Used in the Analysis of Operations in the Biological Opinion and Their Information Flow with Respect to Each Other.

Figure 2.1.4-1 provides a schematic of how the models relate to each other in terms of information flow. Because the CalSimII modeling characterized a projected 2030 climate scenario, that climate condition was represented in all "downstream" modeling that used the CalSimII results.

NMFS notes that several of these models have not been updated to be recalibrated to recent data, especially that of the recent drought. This does introduce an additional component of uncertainty to their application. However, the tools still represent the best options available to NMFS for use in this analysis. Given the approach of applying them to an 82-year sample set of hydrologies, we believe that the tools capture the effects of the majority of years, but we do encourage the developers to capitalize upon the recent extreme conditions to strengthen the application base for these models.

Though salmon life cycle modeling was not used in the previous biological opinion on system-wide water project operations in the Central Valley (i.e., NMFS 2009 Opinion), NMFS has recognized the need to better integrate life cycle models into their assessments of the effects of water operations on the listed anadromous fish species. Peer reviews (Cummins et al. 2008, Anderson et al. 2009, National Research Council 2010) recommended increased use of life cycle

modeling as part of the consultation analyses and provided general recommendations on how NMFS should proceed with further incorporating life cycle modeling into ongoing analyses (Rose et al. 2011).

In response, NMFS has developed a life cycle modeling framework for CV Chinook salmon that is used in this Opinion to allow better evaluation of how complex and interacting management actions affect salmon populations. Specifically, the analyses include results from a model framework developed by the NMFS Southwest Fisheries Science Center to describe salmon population dynamics given water management, habitat restoration, and climate change scenarios (Hendrix et al. 2014, Hendrix et al. 2017). The framework relies upon standard Central Valley physical (i.e., CalSimII, DSM2, HEC-RAS) and chemical (i.e., temperature models, DSM2-QUAL) models to provide a characterization of abiotic conditions for a given scenario. A stage-structured population dynamics model of Chinook salmon links the habitat information to density-dependent stage transitions. These transitions describe the movement, survival, and reproduction that drive the dynamics of salmon populations.

The physical models applied in the BA and relied upon in this Opinion are generalized and simplified representations of a complex water resources system. The models are not predictive models of actual operations, and, therefore, the results cannot be considered as absolute and within a quantifiable confidence interval. For instance, CalSimII is a monthly planning model; it is not calibrated and cannot be used in a real-time predictive manner. CalSimII results are intended to be used in a comparative manner, which allows for assessing the changes in the CVP and SWP system operations and resulting incremental effects between two scenarios. This and any subsequent models that use CalSimII results require caution when used to characterize absolute conditions or conditions on a sub-monthly time step. Similarly, each of the analytical models have limitations to their application and interpretation, and we discuss these limitations in effects analysis sections where they are applied and incorporated into evulation of effects.

Given the nature of modeling outputs and historical data, throughout this Opinion we often analyze effects in a comparative analysis between two scenarios or in relation to baseline conditions to place the difference in context given conditions and operations in the last decade. And although the results of the analytical tools require a more comparative analysis, the analysis for section 7 consultation requires that the effects of the project be evaluated in the aggregate. Our analysis culminates in an aggregate assessment with baseline effects in Sections 2.8 and 2.9 Integration and Synthesis to draw conclusions according to the ESA. Therefore, NMFS used the results of the analysis in the exposure-risk-response framework along with knowledge of the species status and environmental baseline to evaluate the overall conditions that fish experience. The quantitative results of the analytical methods are used to inform this evaluation as much as possible, though, given the limitations of many of the models to comparative analyses, this assessment does rely on a qualitative analysis and application of results.

2.1.4.2 Critical Assumptions in the Analysis

To address the uncertainties identified above related to the PA and the analysis provided in the BA, NMFS used its professional judgement to establish a set of reasonable key assumptions required to address existing data gaps in the BA that are critical to our analysis of effects. General assumptions that were made in filling those data gaps include the following:

- Species presence data are an accurate description of when and where a proportion of a
 particular species can be expected to occur in a particular area. While real-time
 monitoring in any given year may provide an opportunity to fine-tune short-term
 presence information, the available data that characterize both the bulk of presence and
 the tails (that is, smaller proportion) of presence are considered the best information for
 informing exposure and risk.
- The characterization of future conditions incorporated into the PA and Opinion analysis
 is applicable throughout operations until a subsequent consultation on the CVP and SWP
 is completed. The PA and Opinion analyses characterize climate conditions, water
 demands, and build-out as predicted for approximately 2030.
- The project, as characterized in the modeling provided by the BA, does not simulate short-term real-time operations, especially those that are dependent on biological triggers. Because the modeling analysis is based on comparative long-term scenario planning tools, it is not able to emulate the daily operations that would be implemented to manage to biological, water quality, and other constraints. NMFS has analyzed the effects of the project as characterized by an initial approach to operations as identified by the operational criteria of the PA and completed auxiliary analyses when possible to evaluate the effects of real-time operations that are within the operational criteria identified in the PA.
- Results that include confidence intervals to characterize uncertainty are viewed in totality, considering the range of results over the intervals and not simply mean or median values.
- Exposure of a few individuals to a stressor, as indicated by the species presence, does not
 result in no adverse effect. Exposure of a small number of individuals may still result in
 incidental take of those individuals, however few, and this incidental take should not be
 ignored. If the magnitude of effect to those individuals is low, it will be stated as such.

Many of the methods described above focus the analyses on particular aspects of the action or affected species. Key to the overall assessment, however, is an integration of the effects of the PA with each other and with the baseline set of stressors to which the species and critical habitat are also exposed. In addition, the final steps of the analysis require a consideration of the effects of the action within the context of the baseline condition of the species and critical habitat. That is, following the hierarchical approaches outlined above, NMFS combines the effects of the action to determine whether the action is likely to appreciably reduce the likelihood of both the survival and recovery of the species or likely to result in the destruction or adverse modification of critical habitat. Because not all components of the PA were presented with the specificity required to analyze a particular outcome of effect, NMFS' determination is based on a collection of site-specific and framework-level action components. This can explain and result in different conclusions in the BA compared to the Opinion.

2.1.5 Integrating the Effects

The preceding discussions describe the various quantitative and qualitative models, decision frameworks, and ecological foundations for the analyses presented in this Opinion. The purpose of these various methods and tools is to provide a transparent and repeatable mechanism for conducting analyses to determine whether the PA is likely to jeopardize the continued existence

of the listed species or result in the destruction or adverse modification of designated critical habitat.

Many methods described above focus the analyses on particular aspects of the action or affected species. Key to the overall assessment, however, is integration and synthesis which consists of: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat (

Figure 2.1.3-1 and Figure 2.1.3-2). That is, following the hierarchical approaches outlined above, NMFS integrates the effects of the action with the baseline condition as the foundation to determine whether the action is reasonably expected to appreciably reduce the likelihood of both the survival and recovery of listed species in the wild and whether the action is likely to appreciably diminish the value of designated critical habitat for the conservation of the species.

2.1.6 Presentation of the Analysis in this Opinion

Opinions are constructed around several basic sections that in many cases represent specific requirements placed on the analysis by the ESA and implementing regulations. These sections contain different portions of the overall analytical approach described here. This section is intended as a basic guide to the other sections of this Opinion and the analyses that can be found in each section. Every step of the analytical approach described above is presented in this Opinion in either detail or summary form.

Description of the Proposed Action—This section summarizes the proposed Federal action and any interrelated or interdependent actions. This description is the first step in the analysis where we consider the various elements of the action and determine the stressors expected to result from those elements. The nature, timing, duration, and location of those stressors define the action area and provide the basis for our exposure analyses.

Range-wide Status of the Species and Critical Habitat—This section provides the baseline condition for the species and critical habitat at the listing and designation scale. For example, NMFS evaluates the current viability of each salmonid ESU/DPS given its exposure to human activities and natural phenomena such as variations in climate and ocean conditions, throughout its geographic distribution. These reference conditions form the basis for determining whether the PA is likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of critical habitat. Other key analyses presented in this section include critical information on the biological and ecological requirements of the species and critical habitat and the impacts to species and critical habitat from existing stressors.

Environmental Baseline—This section provides the baseline condition for the species and critical habitat within the action area. By regulation, the environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area; the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation; and the impact of state or private actions, which are contemporaneous with the consultation in process on the species and critical habitat. This section will also include anticipated effects of climate change on the species and critical habitat within the action area. In this Opinion, some analysis may be contained within the Status of the Species and Critical Habitat section, due to the large size of the action area (which

entirely or almost entirely encompasses the freshwater geographic ranges of some listed fish species). This section also summarizes the impacts from stressors that will be ongoing in the same areas and times as the effects of the PA. This information forms part of the foundation of our exposure, response, and risk analyses.

Effects of the Proposed Action—This section details the results of the exposure, response, and risk analyses NMFS conducted for effects of the PA on individuals and proportion of the listed species population and PBFs and value for the conservation of the species of critical habitat within the action area. This will include the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02 2007). Indirect effects are those that are caused by the PA and are later in time, but still are reasonably certain to occur. Discussion of results will include identification of uncertainties associated with analytical methods or interpretation and will highlight instances of application of the precautionary principle. In the case of the PA, climate change effects as modeled for a 2030 climate scenario will be incorporated into the analysis by explicit modeling and additional qualitative evaluations to better incorporate more recent climate projections.

Cumulative Effects—This section summarizes the impacts of future non-Federal actions reasonably certain to occur within the action area, as required by regulation. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure, response, and risk posed to individuals of the species and features of critical habitat. Future Federal actions that are unrelated to the PA are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Integration and Synthesis of Effects—Section 2.7, Integration and Synthesis, is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the PA. In this section, we add the effects of the action to the environmental baseline and the cumulative effects, taking into account the status of the species and critical habitat, to formulate NMFS' Opinion as to whether the PA is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution; or (2) appreciably diminish the value of designated critical habitat for the conservation of the species. Discussion will include identification of uncertainties associated with the integration of effects and will highlight instances of application of the precautionary principle.

2.2 Range-wide Status of the Species and Critical Habitat

This section provides a summary of the status of each species that would be adversely affected by the PA. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. This species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR §402.02. This section also provides a summary of the condition of critical habitat throughout the designated area, evaluates the value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that

value for the conservation of the species. A more detailed description of the status of the species and designated critical habitats is provided in Appendix B and in the Environmental Baseline.

2.2.1 Sacramento River Winter-run Chinook Salmon

- First listed as threatened (54 FR 32085; August 4, 1989)
- Reclassified as endangered (59 FR 440; January 4, 1994); reaffirmed as endangered (70 FR 37160; June 28, 2005)
- Designated critical habitat (58 FR 33212; June 16, 1993)

The federally listed ESU of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and designated critical habitat occurs in the action area and may be affected by the PA. Detailed information regarding ESU listing and critical habitat designation history, designated critical habitat, ESU life history, and VSP parameters can be found in Appendix B: Rangewide Status of the Species and Critical Habitat.

Historically, winter-run Chinook salmon population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (National Marine Fisheries Service 2011c). In recent years, since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively (California Department of Fish and Wildlife 2016c). However, from 2007 to 2017, the population has shown a precipitous decline, averaging 2,733 during this period, with a low of 827 adults in 2011 (California Department of Fish and Wildlife 2018b) This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley et al. 2009), drought conditions from 2007 to 2009, low in-river survival (National Marine Fisheries Service 2011c), and extreme drought conditions in 2012 to 2016 (National Marine Fisheries Service 2016c). In 2015, the population was 3,015 adults, slightly above the 2007 to 2012 average, but below the high (17,296) for the last 10 years (California Department of Fish and Wildlife 2016c).

The year 2014 was the third year of a drought that resulted in increased water temperatures in the upper Sacramento River, and egg-to-fry survival to the Red Bluff Diversion Dam (RBDD) was approximately 5 percent (National Marine Fisheries Service 2016c). Due to the anticipated lower than average survival in 2014, hatchery production from LSNFH was tripled (i.e., 612,056 released) to offset the impact of the drought (CVP and SWP Drought Contingency Plan 2014). In 2014, hatchery production represented 83 percent of the total in-river juvenile production. In 2015, egg-to-fry survival was the lowest on record (approximately 4 percent) due to the inability to release cold water from Shasta Dam in the fourth year of the drought. Winter-run Chinook salmon returns in 2016 to 2018 were low, as expected, due to poor in-river conditions for juveniles from brood year 2013 to 2015 during drought years. The 2018 adult winter-run return (2,458) improved from 2017 (1,155), though was similarly dominated by hatchery-origin fish.

Although impacts from hatchery fish (i.e., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala et al. 2012), the winter-run Chinook salmon conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 216,015 per year (2001 to 2018 average) compared to the estimated natural production that passes RBDD, which is 2.9 million per year based on the 2002 to 2018 average (Poytress and Carrillo 2011, U.S. Fish and Wildlife Service 2018a). Therefore, hatchery production typically represents approximately 7 percent of the total

in-river juvenile production in any given year. This percentage of hatchery origin emigrants results in a higher percentage of hatchery-origin spawners, with an average of 21 percent hatchery-origin spawners over the last 18 years (about six generations), putting the population at a moderate risk of extinction (National Marine Fisheries Service 2016c).

The distribution of winter-run Chinook salmon spawning and initial rearing historically included the upper Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Yoshiyama et al. 1998). The construction of Shasta Dam in 1943 blocked access to all these waters except Battle Creek, which also had its own impediments to upstream migration (i.e., a number of small hydroelectric dams situated upstream of the CNFH weir). As of 2019, implementation of the Battle Creek Salmon and Steelhead Restoration Project has completed construction of phase 1 (of 2), which included removal of one fish passage barrier (dam), and construction of NMFS-approved fish screens and ladders at the two remaining dams on North Fork Battle Creek. Phase 2 of the project has completed planning, and is currently in design phase. Additionally, beginning in 2018, winterrun Chinook salmon juveniles produced at LSNFH have been released into North Fork Battle Creek in an effort to jump-start the reintroduction efforts described in the plan (ICF International 2016, U.S. Fish and Wildlife Service 2018b).

Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to winter-run Chinook salmon. Yoshiyama et al. (2001) estimated that in 1938, the upper Sacramento River had a "potential spawning capacity" of approximately 14,000 redds equal to 28,000 spawners. Since 2001, the majority of winter-run Chinook salmon redds have occurred in the first 10 miles downstream of Keswick Dam. Most components of the winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam (National Marine Fisheries Service 2014b).

The greatest risk factor for winter-run Chinook salmon lies within its spatial structure (National Marine Fisheries Service 2011c). The winter-run Chinook salmon ESU comprises only one population that spawns below Keswick Dam. The remnant and remaining population cannot access 95 percent of their historical spawning habitat and must, therefore, be artificially maintained in the Sacramento River by spawning gravel augmentation, hatchery supplementation, and regulation of the finite cold water pool behind Shasta Dam to reduce water temperatures.

Winter-run Chinook salmon require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure. The Central Valley Salmon and Steelhead Recovery Plan (National Marine Fisheries Service 2014b) includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats in Battle Creek as well as upstream of Shasta Dam (National Marine Fisheries Service 2014b). As mentioned above, in 2017 and 2018 action was taken to initiate the reintroduction of winter-run Chinook salmon to Battle Creek using the progeny of captive broodstock from LSNFH(U.S. Fish and Wildlife Service 2018b). This decision to spawn captive broodstock and use their progeny to initiate reintroduction of Sacramento River winter-run Chinook salmon into historic spawning habitats of Battle Creek was called the winter Chinook salmon "Jumpstart" Project (U.S. Fish and

Wildlife Service 2018b). In March and early April of 2018, progeny of the winter-run Chinook salmon captive broodstock were released into the North Fork Battle Creek. Currently, the plan is for this Jumpstart Project to continue until a "Transition Plan" is developed to merge the Jumpstart Project with the Reinitiation Plan (U.S. Fish and Wildlife Service 2018b).

Winter-run Chinook salmon embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. The only remaining population of winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates et al. 2008). The long-term projection of how the CVP and SWP will operate incorporates the effects of potential climate change in three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or earlier spring snow melt (U.S. Bureau of Reclamation 2008). Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008, Beechie et al. 2012, Dimacali 2013). These factors will compromise the quantity and/or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam. It is imperative for additional populations of winter-run Chinook salmon to be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (National Marine Fisheries Service 2014b).

2.2.1.1 Summary of the Sacramento River Winter-run Chinook Salmon Evolutionarily Significant Unit Viability

There are several criteria that would qualify the winter-run Chinook salmon population at moderate risk of extinction (continued low abundance, a negative growth rate over two complete generations, significant rate of decline since 2006, increased hatchery influence on the population, and increased risk of catastrophe), and because there is still only one population that spawns below Keswick Dam, the winter-run Chinook salmon ESU is at high risk of extinction in the long term (Lindley et al. 2007). The extinction risk for the winter-run Chinook salmon ESU has increased from moderate risk to high risk of extinction since 2005, and several listing factors have contributed to the recent decline, including drought and poor ocean conditions (National Marine Fisheries Service 2016c). Thus, large-scale fish passage and habitat restoration actions are necessary for improving the winter-run Chinook salmon ESU viability (National Marine Fisheries Service 2016c).

2.2.2 Critical Habitat and Physical or Biological Features for Sacramento River Winterrun Chinook Salmon

The critical habitat designation for Sacramento River winter-run Chinook salmon lists the PBFs (58 FR 33212; June 16, 1993), which are described in Appendix B. This designation includes the following waterways, bottom and water of the waterways, and adjacent riparian zones: the Sacramento River from Keswick Dam (river mile [RM] 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge (58 FR 33212; June 16, 1993). NMFS clarified that "adjacent riparian zones" are limited to only those

areas above a stream bank that provide cover and shade to the nearshore aquatic areas (58 FR 33212; June 16, 1993). Although the bypasses (e.g., Yolo, Sutter, and Colusa) are not currently designated critical habitat for winter-run Chinook salmon, NMFS recognizes that they may be utilized when inundated with Sacramento River flood flows, and are important rearing habitats for juvenile winter-run. Also, juvenile winter-run Chinook salmon may use tributaries of the Sacramento River for non-natal rearing (Maslin et al. 1997, Pacific States Marine Fisheries Commission 2014, Phillis et al. 2018).

2.2.2.1 Summary of Winter-run Chinook Salmon Critical Habitat

Currently, many of these PBFs are degraded and provide limited high quality habitat. Factors that lessen the quality of the migratory corridor for juveniles include unscreened diversions, altered flows in the Delta, Sacramento River and its tributaries, and the lack of floodplain habitat. In addition, water operations that limit the extent of cold water below Shasta Dam have reduced the available spawning habitat and degraded juvenile rearing and outmigration habitat (based on water temperature). Although the critical habitat for winter-run Chinook salmon has been highly degraded, the importance of the reduced spawning habitat, migratory corridors, and rearing habitat that remains is of high value for the conservation of the species.

2.2.3 Central Valley Spring-run Chinook Salmon

- Listed as threatened (64 FR 50394; September 16, 1999); reaffirmed as threatened (70 FR 37160; June 28, 2005)
- Designated critical habitat (70 FR 52488; September 2, 2005)

The federally listed ESU of CV spring-run Chinook salmon and designated critical habitat occur in the action area and may be affected by the PA. Detailed information regarding ESU listing and critical habitat designation history, designated critical habitat, ESU life history, and VSP parameters can be found in Appendix B.

Historically, spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (California Department of Fish and Game 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1908, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (California Department of Fish and Game 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 to 500,000 adults returning annually (California Department of Fish and Game 1990). Currently, CV spring-run Chinook salmon are extirpated from the San Joaquin River due to habitat loss (National Marine Fisheries Service 2016a).

Monitoring the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates that some spawning occurs in the river. Genetic introgression between fall-run and spring-run CV Chinook salmon populations has likely occurred due to lack of physical separation, temporal overlap, and hatchery practices (California Department of Water Resources 2001). Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best

trend indicators for the CV spring-run Chinook salmon ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance (Table B-3 in Appendix B). The FRFH spring-run Chinook salmon population represents the only remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population and the potential development of a conservation strategy for the hatchery program (70 FR 37160; June 28, 2005). Hatchery-produced CV spring-run Chinook salmon may affect ESU diversity through (1) introgression with CV fall-run Chinook salmon due to overlap in spawn timing; (2) straying of FRFH spring-run into natural-origin CV spring-run spawning habitat; and (3) disproportionately high levels of returning spawners in comparison to natural-origin fish (National Marine Fisheries Service 2016a).

The Central Valley TRT estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Lindley et al. 2004). Of these populations, only three independent populations currently exist (Mill, Deer, and Butte creeks, tributary to the upper Sacramento River), and they represent only the northern Sierra Nevada diversity group (National Marine Fisheries Service 2014b). Additionally, smaller, dependent, populations in Antelope and Big Chico creeks and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (California Department of Fish and Game 1998). The northwestern California diversity group contains two small persisting populations, in Clear and Beegum creeks. In the basalt and porous lava diversity group, in addition to a potential returning population to the Sacramento River, downstream of Keswick Dam, a small population in Battle Creek is currently persisting. In the San Joaquin River basin, the southern Sierra Nevada diversity group, observations in the last decade suggest that spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2014). Restoration efforts in the Stanislaus, Tuolumne, and Merced rivers and reintroduction of CV spring-run Chinook salmon in the San Joaquin River are beneficial to the spatial structure and genetic diversity of the ESU will benefit (National Marine Fisheries Service 2016a).

The CV spring-run Chinook salmon ESU comprises two known genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the northern Sierra Nevada diversity group spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retain genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised by introgression with the fall-run ESU (Good et al. 2005, Garza et al. 2008, Cavallo et al. 2011).

Because the populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on VSP parameters in these watersheds. Over the long term, these three remaining populations are considered to be vulnerable to anthropomorphic and naturally occurring catastrophic events. The viability assessment of CV spring-run Chinook salmon conducted during NMFS' 2010 status review (National Marine Fisheries Service 2011a) found that the biological status of the ESU had worsened since the last status review (2005). In 2012 and 2013, most tributary populations increased in returning adults, averaging over 13,000. However, 2014 returns were lower again, just over 5,000 fish, indicating the ESU remains highly fluctuating. The most recent status review, conducted in 2015 (National Marine Fisheries Service 2016a), looked at promising increasing populations in 2012 to 2014. However, CDFW has documented critically low spring-run Chinook salmon adult returns to Mill

and Deer creeks for the fourth consecutive year, due in part, to one of California's most severe and prolonged droughts on record (December 2011 to March 2017). From 2015 through 2018, both Mill and Deer creeks spring-run Chinook salmon populations had adult returns below 500. The final 2018 escapement estimates for Mill and Deer creeks were 152 and 159 CV spring-run Chinook salmon, respectively (California Department of Fish and Wildlife 2019). These estimates are among the lowest number of adults returning to Mill and Deer Creeks since records began in 1960. Mill and Deer Creeks spring-run Chinook salmon represent two of only three extant independent Chinook salmon populations in California's Central Valley, and therefore are vital to the health of the CV spring-run Chinook salmon ESU. In response to the recent reduction in adult escapement, NMFS and CDFW are jointly developing an Emergency Spring-run Action Plan, which aims to identify and outline the implementation of immediate, targeted efforts that are vital for stabilizing the populations that are most at risk (Mill, Deer, and Butte creeks). Immediate management actions under consideration include efforts to increase flows, possible implementation of a supplementation program (utilizing hatchery-origin CV spring-run Chinook salmon), and completion of fish passage improvement projects.

CV spring-run Chinook salmon adults are vulnerable to climate change because they oversummer in freshwater streams before spawning in autumn (Thompson et al. 2011). CV spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia (usually input from springs) will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures (National Marine Fisheries Service 2016a). In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser et al. 2013).

2.2.3.1 Summary of the Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit Viability

In summary, the extinction risk for the CV spring-run Chinook salmon ESU remains at moderate risk of extinction (National Marine Fisheries Service 2016a). However, based on the severity of the drought and the low escapements, as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015, there is concern that these CV spring-run Chinook salmon strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (National Marine Fisheries Service 2016a). This predicted trend has been validated in recent years through escapement data collected by CDFW for Mill and Deer creeks (California Department of Fish and Wildlife 2019). With adult returns below 500 individuals for the fourth consecutive year (2015-2018), these populations are at an increased risk of extinction (Lindley et al. 2007). In response to these alarming trends, CDFW and NMFS intend to implement the suite of actions described in the draft Emergency Spring-run Action Plan as soon as possible upon finalizing the plan.

2.2.4 Critical Habitat and Physical or Biological Features for Central Valley Spring-run Chinook Salmon

The critical habitat designation for CV spring-run Chinook salmon lists the PBFs (70 FR 52488; September 2, 2005), which are described in Appendix B. In summary, the PBFs for CV spring-run Chinook salmon critical habitat include freshwater spawning sites, freshwater migratory habitat, freshwater rearing sites, and estuarine habitat. The geographical range of designated critical habitat includes stream reaches of the Feather, Yuba, and American rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and the Sacramento River downstream to the Delta, as well as portions of the northern Delta (70 FR 52488; September 2, 2005).

2.2.4.1 Summary of Central Valley Spring-run Chinook Salmon Critical Habitat

Currently, many of the PBFs of CV spring-run Chinook salmon critical habitat are degraded and provide limited high-quality habitat. Factors that lessen the quality of migratory corridors for juveniles include unscreened or inadequately screened diversions, altered flows in the Delta and mainstem Sacramento River, scarcity of complex in-river cover, in-river predation, degraded water quality, suboptimal water temperatures, and the lack of floodplain habitat. Although the current conditions of CV spring-run Chinook salmon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain are considered to have high intrinsic value for the conservation of the species.

2.2.5 California Central Valley Steelhead Distinct Population Segment

- Originally listed as threatened (63 FR 13347; March 19, 1998), reaffirmed as threatened (71 FR 834; January 5, 2006)
- Designated critical habitat (70 FR 52488; September 2, 2005)

The federally listed DPS of CCV steelhead and designated critical habitat occur in the action area and may be affected by the PA. Detailed information regarding DPS listing and critical habitat designation history, designated critical habitat, DPS life history, and VSP parameters can be found in Appendix B.

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Current abundance data are limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data are the most reliable, as redd surveys for CCV steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

CCV steelhead returns to CNFH increased from 2011 to 2015 (see Appendix B for further information). After reaching a low of only 790 fish in 2010, the years 2013 to 2015 averaged 2,854 fish. Natural-origin adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200 to 300 fish each year, ranging from 252 to 610 from 2010 to 2017, respectively (Figure B-8 in Appendix B).

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of approximately 123 redds have been counted on the American River from 2002 to 2018 (Figure B-9 in Appendix B; data from (Cramer Fish Sciences 2016, American River Group 2017, 2018)). An average of 183 redds have been counted in Clear Creek from 2001 to 2017

following the removal of Saeltzer Dam, which allowed steelhead access to additional spawning habitat. The Clear Creek redd count data estimated a range from 100 to 1,023 spawning adult steelhead on average each year, indicating an upward trend in abundance since 2006 (U.S. Fish and Wildlife Service 2015a).

An estimated 100,000 to 300,000 naturally-produced juvenile steelhead leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (natural-origin) steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 steelhead smolts are produced naturally each year in the Central Valley. Updated through 2017, the trawl data indicate that the level of natural production of steelhead has remained very low since the 2011 status review (National Marine Fisheries Service 2011b), suggesting a decline in natural production based on consistent hatchery releases. Catches of steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS as well as the production of natural-origin steelhead relative to hatchery steelhead (California Department of Fish and Wildlife 2017b). The overall catch of steelhead has declined dramatically since the early 2000s, with an overall average of 2,795 from 2004 to 2017, as measured by expanded salvage. The percentage of natural-origin (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 34 percent since a high of 93 percent in 1999.

About 80 percent of the historical spawning and rearing habitat once used by anadromous steelhead in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good et al. 2005, National Marine Fisheries Service 2016b). Most of the steelhead populations in the Central Valley have a high hatchery-origin component, including those from Battle Creek (adults intercepted at the Coleman NFH weir), American River, Feather River, and Mokelumne River.

The continued decline of CCV steelhead abundance and population growth rates is largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006), and is likely influenced by changes to the underlying genetic and environmental factors that support the anadromous phenotype of this species (Kendall et al. 2014). Past research has emphasized that genetic makeup (Pearse et al. 2014), growth and survival in freshwater, survival during migration and at sea, and asymptotic sizes achievable in freshwater are likely key factors in determining life-history expression and adaptation (e.g., Satterthwaite et al. 2009, Satterthwaite et al. 2010). However, despite decades of research on this topic, reviewed by Kendall et al. (2014), considerable uncertainty remains regarding the factors that drive the expression of anadromy in *O. Mykiss*.

Though genetic analyses conducted over the last twenty years illustrate that there is still significant genetic population structure among steelhead populations within the California Central Valley, they also provide evidence of recent reduction in population size for steelhead throughout the Central Valley (Nielson et al. 2005). Additionally, historical hatchery practices have had a profound influence on the genetic makeup of CCV steelhead. Garza et al. (2008) analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely

related to below barrier fish from other watersheds than to steelhead above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers. The genetic diversity of CCV steelhead is also compromised by hatchery-origin fish, which likely comprise the majority of the annual spawning runs, placing the natural-origin population at a high risk of extinction (Lindley et al. 2007). Steelhead in the Central Valley historically consisted of both summer-run and winter-run Chinook salmon migratory forms. Only winter-run (ocean-maturing) steelhead are currently found in Central Valley rivers and streams, as summer-run steelhead have been extirpated (McEwan and Jackson 1996, Moyle 2002).

Although CCV steelhead will experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile CCV steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile steelhead, which range from 57°F to 66°F (14°C to 19°C). However, one study did find that juvenile steelhead could achieve average growth rates exceeding 1mm/day in the American River even when summer water temperatures regularly exceed 20°C (Sogard et al. 2012). It is unknown if this observation is applicable to steelhead in other Central Valley rivers, but such results from Sogard et al. (2012), and other salmonid-focused studies (Manhard et al. 2018), highlight the interactive role of water temperature and food availability in modulating growth in salmonids. Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough et al. 2001). In fact, McCullough et al. (2001) recommended an optimal incubation temperature at or below 52°F to 55°F (11°C to 13°C). Successful smoltification in steelhead may be impaired by temperatures above 54°F (12°C), as reported in Richter and Kolmes (2005). As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support natural-origin steelhead populations.

2.2.5.1 Summary of California Central Valley Steelhead Distinct Population Segment Viability

All indications are that natural-origin CCV steelhead have continued to decrease in abundance and in the proportion of natural-origin to hatchery-origin fish over the past 25 years (Good et al. 2005, National Marine Fisheries Service 2016b); the long-term trend remains negative. Hatchery-origin production and returns are dominant over natural-origin fish. Most natural-origin CCV steelhead populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery-origin fish relative to natural-origin fish.

In summary, the 5-year status review of the CCV steelhead DPS (National Marine Fisheries Service 2016b) found that the status of the DPS appears to have remained unchanged since the 2011 status review (National Marine Fisheries Service 2011b), and the DPS is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

2.2.6 Critical Habitat and Physical or Biological Features for California Central Valley Steelhead

The critical habitat for CCV steelhead lists the PBFs (70 FR 52488; September 2, 2005), which are described in Appendix B. In summary, the PBFs include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The geographical extent of designated critical habitat includes, but is not limited to, the following: Sacramento, Feather, and Yuba rivers; Clear, Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries; and the waterways of the Delta.

2.2.6.1 Summary of California Central Valley Steelhead Critical Habitat

Many of the PBFs of CCV steelhead critical habitat are degraded and provide limited high quality habitat. Passage to historical spawning and juvenile rearing habitat has been largely reduced due to dam construction throughout the Central Valley. Levee construction has also degraded the freshwater rearing and migration habitat and estuarine areas as riparian vegetation has been removed, reducing habitat complexity and food resources and resulting in many other ecological effects. Contaminant loading and poor water quality (including warm water temperatures) in central California waterways pose a threat to CCV steelhead, their habitat, and food resources. Additionally, due to reduced access to historical habitat, genetic introgression is occurring because natural-origin fish are interacting with hatchery-origin fish, providing the potential to reduce the long-term fitness and survival of this species.

Although the current conditions of CCV steelhead critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in the Sacramento-San Joaquin River watershed and the Delta are considered to have high intrinsic value for the conservation of the species as they are critical to ongoing recovery efforts.

2.2.7 Southern Distinct Population Segment of North American Green Sturgeon

- Listed as threatened (71 FR 17757; April 7, 2006)
- Designated critical habitat (74 FR 52300; October 9, 2009)

The federally listed sDPS of North American green sturgeon and its designated critical habitat occur in the action area and may be affected by the PA. Detailed information regarding DPS listing and critical habitat designation history, designated crucial habitat, DPS life history, and VSP parameters can be found in Appendix B. Although McElhany et al. (2000) specifically addresses viable populations of salmonids, NMFS believes that the concepts and viability parameters in McElhany et al. (2000) can be applied to sDPS green sturgeon (see Analytical Approach section 2-1).

Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. During late summer and early fall, subadults and non-spawning adult green sturgeon can frequently be found aggregating in estuaries along the Pacific coast (Emmett et al. 1991, Moser and Lindley 2007). Using polyploid microsatellite data, Israel et al. (2009) found that green sturgeon within the Central Valley of California belong to the sDPS. Additionally, acoustic tagging studies have found that green sturgeon found spawning within the Sacramento River are exclusively sDPS green sturgeon (Lindley et al. 2011). In waters inland from the Golden Gate Bridge in California, sDPS green sturgeon are known to range through the

estuary and Delta and up the Sacramento, Feather, and Yuba rivers (Israel et al. 2009, S.P. Cramer & Associates 2011, Seesholtz et al. 2014). It is unlikely that green sturgeon utilize areas of the San Joaquin River upriver of the Delta with regularity, and spawning events are thought to be limited to the upper Sacramento River and its tributaries. There is no known modern usage of the upper San Joaquin River, and adult green sturgeon spawning has not been documented (Jackson and Van Eenennaarn 2013). However, there was a sighting of an adult green sturgeon in the Stanislaus River in October 2017.

Recent research indicates that the sDPS is composed of a single, independent population, which principally spawns in the mainstem Sacramento River (Israel et al. 2009), and also spawns opportunistically in the Feather River and possibly even the Yuba River (S.P. Cramer & Associates 2011, Seesholtz et al. 2014). Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent, but unconfirmed, extirpation of spawning populations from the San Joaquin River narrows the available habitat within their range, offering fewer habitat alternatives. Whether sDPS green sturgeon display diverse phenotypic traits, such as ocean behavior, age at maturity, and fecundity, or if there is sufficient diversity to buffer against long-term extinction risk is not well-understood. It is likely that the diversity of sDPS green sturgeon is low, given recent abundance estimates (National Marine Fisheries Service 2015a).

Trends in abundance of sDPS green sturgeon have been estimated from two long-term data sources: (1) salvage numbers at the State and Federal pumping facilities (Figure B-16 in Appendix B), and (2) incidental catch of green sturgeon by the CDFW's white sturgeon sampling/tagging program. Historical estimates from these sources are expected to be unreliable, as sDPS green sturgeon were likely not taken into account in incidental catch data, and salvage does not capture range-wide abundance in all water year types. Recently, more rigorous scientific inquiry has been undertaken to generate abundance estimates (Israel and May 2010, Mora et al. 2015). A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities: the Skinner Delta Fish Protection Facility (SDFPF) and the Tracy Fish Collection Facility (TFCF). These data should be interpreted with some caution; operations and practices at the facilities have changed over the decades, which may affect the salvage data shown in Figure B-16 of Appendix B. The salvage data likely indicate a high production year versus a low production year qualitatively, but cannot be used to rigorously quantify abundance.

Since 2010, more robust estimates of sDPS green sturgeon have been generated. As part of a doctoral thesis at U.C. Davis, Ethan Mora has been using acoustic telemetry as well as Dual-frequency identification sonar (DIDSON) to locate green sturgeon in the Sacramento River and to derive an adult spawner abundance estimate (Mora et al. 2015). Results of these surveys estimate an average annual spawning run of 223 (DIDSON) and 236 (telemetry) fish. These estimates do not include the number of spawning adults in the lower Feather or Yuba rivers, where green sturgeon spawning was recently confirmed (Seesholtz et al. 2014).

The parameters of green sturgeon population growth rate and carrying capacity in the Sacramento Basin are poorly understood. Larval count data show enormous variance among years. In general, sDPS green sturgeon year class strength appears to be highly variable with overall abundance dependent upon a few successful spawning events (National Marine Fisheries

Service 2010). Other indicators of productivity, such as data for cohort replacement ratios and spawner abundance trends, are not currently available for sDPS green sturgeon.

The sDPS green sturgeon spawn primarily in the Sacramento River in the spring and summer. The Anderson-Cottonwood Irrigation District Diversion Dam (ACID) is considered the upriver extent of sDPS green sturgeon migration in the Sacramento River (71 FR 17757; April 7, 2006). The upriver extent of sDPS green sturgeon spawning, however, is approximately 30 kilometers downriver of ACID because water temperatures in this section of the river are too cold for spawning. Thus, if water temperatures increase with climate change, temperatures adjacent to ACID may remain within tolerable levels for the embryonic and larval life stages of green sturgeon, but temperatures at spawning locations lower in the river may be more affected. It is uncertain, however, if green sturgeon spawning habitat exists closer to ACID, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of sDPS green sturgeon in other accessible habitats in the Central Valley (i.e., the Feather River) is limited, in part, by late spring and summer water temperatures (National Marine Fisheries Service 2015a). Similar to salmonids in the Central Valley, sDPS green sturgeon spawning in tributaries to the Sacramento River is likely to be further limited if water temperatures increase and higher elevation habitats remain inaccessible.

2.2.7.1 Summary of Green Sturgeon Southern Distinct Population Segment Viability

The viability of sDPS green sturgeon is constrained by factors including a small population size, lack of multiple populations, and concentration of spawning sites into few locations. The risk of extinction is believed to be moderate (National Marine Fisheries Service 2010). Although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (National Marine Fisheries Service 2010). Lindley et al. (2008), in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over a large timescale; this would apply to green sturgeon. The most recent 5-year status review for sDPS green sturgeon found that some threats to the species have been eliminated, such as take from commercial fisheries and removal of some passage barriers (National Marine Fisheries Service 2015a). Since many of the threats cited in the original listing still exist, the threatened status of the DPS is still applicable (National Marine Fisheries Service 2015a).

2.2.8 Critical Habitat Physical or Biological Features for Southern Distinct Population Segment Green Sturgeon

The designated critical habitat for sDPS green sturgeon lists the PBFs (74 FR 52300; October 9, 2009), which are described in Appendix B. In summary, the PBFs include the following for both freshwater riverine systems and estuarine habitats: food resources, water flow, water quality, migratory corridor, depth, and sediment quality, as well as substrate type or size for just freshwater riverine systems. In addition, the PBFs include migratory corridor, water quality, and food resources in nearshore coastal marine areas. The geographical range of designated critical habitat includes the following:

In freshwater, the geographic range includes:

- The Sacramento River from the Sacramento I-Street Bridge to Keswick Dam, including the Sutter and Yolo bypasses and the lower American River from the confluence with the mainstem Sacramento River upstream to the highway 160 bridge
- The Feather River from its confluence with the Sacramento River upstream to the Fish Barrier Dam
- The Yuba River from the confluence with the Feather River upstream to Daguerre Point Dam
- The Sacramento-San Joaquin Delta (as defined by California Water Code section 12220, except for listed excluded areas)
- In coastal bays and estuaries, the geographical range includes:
 - San Francisco, San Pablo, Suisun, and Humboldt bays in California
 - Coos, Winchester, Yaquina, and Nehalem bays in Oregon
 - Willapa Bay and Grays Harbor in Washington
 - o The lower Columbia River estuary from the mouth to river kilometer (RK) 74

In coastal marine waters, the geographic range includes all United States coastal marine waters out to the 60-fathom-depth bathymetry line, from Monterey Bay, California, north and east to include the Strait of Juan de Fuca, Washington.

2.2.8.1 Summary of Southern Distinct Population Segment Green Sturgeon Critical Habitat

Currently, many of the PBFs of sDPS green sturgeon are degraded and provide limited high quality habitat. Factors that lessen the quality of migratory corridors for juveniles include unscreened or inadequately screen diversions, altered flows in the Delta, and presence of contaminants in sediment. Although the current conditions of green sturgeon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in both the Sacramento-San Joaquin River watersheds, the Delta, and nearshore coastal areas are considered to have high intrinsic value for the conservation of the species.

2.2.9 Southern Resident Killer Whale Distinct Population Segment

- Listed as endangered (70 FR 69903; November 18, 2005)
- Designated critical habitat (71 FR 69054; November 29, 2006)

The Federally listed DPS of Southern Resident Killer Whale (SRKW) occurs in the action area and may be affected by the PA. Designated critical habitat for SRKW does not occur within the action area of the PA.

SRKW occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (National Marine Fisheries Service 2008b, Hanson et al. 2013, Carretta et al. 2017). Three pods – J, K, and L – make up the SRKW population. During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982, Ford et al. 2000, Krahn et al. 2002, Hauser et al. 2007). In general, the three pods are increasingly present in May and June and spend a considerable amount of time in inland waters through September. Sightings in late fall decline as

the whales shift to the outer coastal waters. Satellite-linked tag deployments have also provided more data on the SRKW movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months. The limited range of the sightings or acoustic detections of J pod in coastal waters, the lack of coincident occurrence during the K and L pod sightings, and the results from satellite tagging in 2012 to 2016 (NWFSC unpublished data) indicate J pod's limited occurrence along the outer coast and extensive occurrence in inland waters.

At present, the SRKW population has declined to the lowest levels seen in over thirty years. During an international science panel review of the effects of salmon fisheries (Hilborn et al. 2012), the panel stated that during 1974 to 2011, the population experienced a realized growth rate of 0.71 percent, from 67 individuals to 87 individuals. However, as of December 2018, the population has decreased to only 74 whales, a historical low in the last 30 years with a current realized growth rate (from 1974 to 2017) at half of the previous estimate described in the science panel report; 0.29 percent. There is representation in all three pods, with 22 whales in J pod, 18 whales in K pod and 34 whales in L pod.

Seasonal mortality rates among SRKW may be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer season. Additionally, stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004).

Recent updates to population viability analyses suggest a downward trend in population growth projected over the next 50 years (National Marine Fisheries Service 2016e). This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (National Marine Fisheries Service 2016e). To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3 percent growth rate, the acoustic disturbance would need to be reduced in half and the Chinook abundance would need to be increased by 15 percent (Lacy et al. 2017).

Several factors identified in the final recovery plan for SRKW may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. When prey is scarce, SRKW likely spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition, can lead to reduced body size of individuals and to lower reproductive and survival rates of a population (Trites and Donnelly 2003). Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact the whales. Modeling exercises have attempted to identify which threats are most significant to survival and recovery (Lacy et al. 2017) and available data suggests that all of the threats are potential limiting factors (National Marine Fisheries Service 2008b).

2.2.9.1 Summary of Southern Resident Killer Whale DPS Viability

In summary, the SRKW DPS is at risk of extinction primarily from low abundance and impaired survival and fecundity, especially in recent years. Major threats to this species include limitations in available preferred prey (Chinook salmon), vessel and sound impacts, contaminants, and climate change. SRKW would benefit from the recovery of Chinook salmon populations and increased access to prey, as well as protections to reduce the impacts of vessels and sound, as well as reduced exposure to contaminants in prey items and in the marine environment.

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). There are two action areas identified in this biological opinion. Generally, for listed anadromous fish, the action area encompasses the following reservoirs, rivers, and the land between the levees adjacent to the rivers: (1) Shasta and Keswick reservoirs, and the Sacramento River from Keswick Reservoir downstream to and including the Sacramento—San Joaquin Delta; (2) Whiskeytown Reservoir, and Clear Creek from Whiskeytown Reservoir to its confluence with the Sacramento River;

(3) Folsom Reservoir, Lake Natoma, and the American River from Lake Natoma downstream to its confluence with the Sacramento River; (4) New Melones Reservoir, and the Stanislaus River from New Melones Reservoir to its confluence with the San Joaquin River; (5) San Joaquin River from the confluence of the Stanislaus River downstream to and including the Sacramento—San Joaquin Delta; and (6) San Francisco Bay and Suisun Marsh. For purposes of the SRKW DPS only, the action area includes nearshore coastal areas in California, Oregon, and Washington, not including Puget Sound. Additionally, the areas affected by the PA include Shasta, Whiskeytown, Folsom, and New Melones dams and reservoirs because they are influenced by the operation of CVP and SWP.

Starting in 2016, Friant Dam and the Upper San Joaquin River have been hydrologically reconnected to the Delta through the release of San Joaquin River Restoration Program flows. However, operations of Friant Dam are not included in the PA. Therefore, the action area within the mainstem San Joaquin River is limited to the section from the confluence of the Stanislaus River downstream to, and including, the Sacramento–San Joaquin Delta.

The CVP and SWP affects the abundance of Central Valley Chinook salmon originating from the Sacramento and San Joaquin rivers. Central Valley Chinook salmon is a prey species for SRKW. The action area for SRKWs is the area of co-occurrence of Central Valley Chinook salmon and SRKWs in the nearshore coastal waters of California, Oregon, and Washington, excluding Puget Sound.

2.4 Environmental Baseline

This section describes the past and ongoing factors leading to the status of ESA-listed species and the condition of their critical habitat within the action area. As defined by ESA regulations, the environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the

consultation in process (50 CFR 402.14 1986). The key purpose of the Environmental Baseline is to describe the condition of the listed species/critical habitat in the Action Area.

Per this regulatory definition, past and present CVP/SWP operations are federal actions in the action area, and thus the impacts associated with those federal actions previously consulted on become part of the environmental baseline for subsequent consultations. It is important to note that for ESA section 7, each time the operations of the CVP/SWP are consulted on (e.g., 2004 and 2008/2009), the impacts of past and present operations of the CVP/SWP become part of the environmental baseline for subsequent consultations. The operations of the CVP/SWP over time is not one continuous Federal Action in the context of ESA compliance. Rather, the CVP/SWP action described and analyzed in the 2004 Opinion was discrete from the CVP/SWP action described and analyzed in 2008/2009, which again, is discrete from the proposed CVP/SWP action analyzed in this Opinion. Each proposed action had specific components and operating criteria, and is therefore considered separate federal actions requiring separate ESA section 7 consultations and analyses.

Reclamation established a WOA scenario as part of the BA's Environmental Baseline to isolate and define potential effects of the PA apart from effects of non-proposed actions. The model run representing this scenario does not include CVP and SWP operations, but does include the operations of non-CVP and non-SWP facilities, such as operation of public and private reservoirs on the Yuba, Tuolumne, and Merced rivers. NMFS considers the without-action scenario to represent effects related to the existence of CVP and SWP facilities. The without-action scenario provides context for how these facilities have shaped the habitat conditions for species and critical habitat in the action area. The environmental baseline section in Reclamation's BA includes a WOA scenario and also the past, present, and ongoing impacts of human and natural factors, including the present and ongoing effects of current operations that were considered in prior consultations.

The NMFS analysis recognizes that the PA is not simply an ongoing action that projects the status quo into the future, but a new operational approach with a different suite of operational criteria and associated effects that must be distinguished and analyzed on their own. NMFS' analysis traces and evaluates the proposed action. With respect to dams, NMFS treats the existence of dams and some past operations in the baseline with respect to future effects on the status of the species and habitat conditions. NMFS considers in the effects analysis how future daily, monthly and seasonal operational decisions to store or release water from CVP/SWP reservoirs can have effects downstream and through the Delta, in various timescales. Depending on the flow and quality (e.g., temperature) of the water released, the timing and location, and life stage and species affected, these effects can be both beneficial or adverse.

2.4.1 Landscape Scale Factors Affecting Listed Species in the Central Valley

Since settlement of the Central Valley in the mid-1800s, populations of native Chinook salmon, steelhead, and green sturgeon have declined dramatically, largely due to factors that completely reshaped the aquatic ecosystem such as dam construction, water management, hydropower facilities, levee construction, and before those, gold mining. These land use changes eliminated important habitats, or blocked access to them, and reduced the abundance, productivity, and distribution of Central Valley salmonids and sturgeon. Habitat simplification, fishing, hatchery impacts, and other stressors led to the loss of genetic and phenotypic (life history, morphological,

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behavioral, and physiological) diversity in Central Valley salmonids, which has reduced their capacity to cope with a variable and changing climate (Herbold et al. 2018). Given the reliance of SRKW on Chinook salmon prey resources that include Central Valley Chinook salmon (described further in Section 2.4.7.4 Factors Affecting the Prey of Southern Residents in the Action Area), these factors have also been, and continue to, affect the available prey base of SRKWs. Land use changes to support and protect California's rapidly increasing human population combined with substantial and widespread water development, including the construction and operation of the CVP/SWP, have been accompanied by significant declines in nearly all species of native fish (State Water Resources Control Board 2017b). Recent evidence from a study that used a novel combination of tagging technologies suggests that the freshwater and estuarine environment has been so dramatically altered by habitat loss and water management that the anadromous life history strategy may no longer be sustainable for Central Valley salmon (Michel 2018).

Dams, levees, water management, and gold mining are the main landscape-scale factors that have shaped the Central Valley environment to what it is today, with climate change providing additional impacts. These landscape-scale factors and their impact on Central Valley listed species and critical habitat are discussed below, followed by a section on more localized, but also important factors affecting listed species in the Central Valley. Included is a description of the status of each Central Valley anadromous fish species and their critical habitat in the action area. The Environmental Baseline chapter wraps up with a discussion on the status of Southern Resident killer whales and an overview of the factors affecting their prey.

2.4.1.1 Dams

The construction of dams around the Central Valley has blocked anadromous salmonids and sturgeon from most of their historic spawning and initial rearing habitat, eradicating most historic populations of winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon. Between 72 to 90 percent of the original Chinook salmon spawning and holding habitat in the Central Valley drainage is no longer accessible due to dam construction (Figure 2.4.1-1) (Yoshiyama et al. 2001);(Cummins et al. 2008). Winter-run Chinook salmon lost three of its four historic spawning populations with the construction of Keswick and Shasta Dams. Perhaps 15 of the 18 or 19 historical populations of CV spring-run Chinook salmon are extirpated, with their entire historical spawning habitats upstream from impassable dams (Lindley et al. 2007). Currently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of the historical populations of steelhead (Lindley et al. 2006). Impassable barriers are considered to be the main threat to sDPS green sturgeon as migration corridors are blocked and migration cues (water flow) are altered (National Marine Fisheries Service 2018g). The existence of these impassable barriers have significant adverse effects on species in the past, present and future.

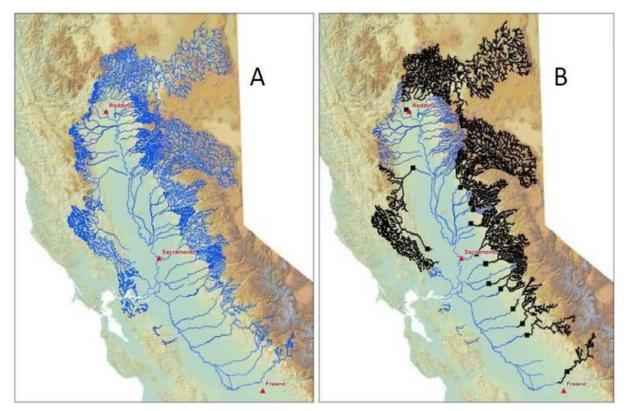


Figure 2.4.1-1 Historical habitat accessible to salmonids (A, in blue) and lost upstream habitat (B, in black) from construction of impassible dams (black squares). Remaining anadromous habitat for multiple life stages of salmon is largely confined to the valley floor (B, in blue).

2.4.1.2 Levees

The construction of levees throughout the Sacramento and San Joaquin River watersheds has resulted in a landscape in which less than 5 percent of the native wetland, riparian, and floodplain habitats remain (Whipple et al. 2012). Ninety-three percent of historic floodplain rearing habitat is no longer accessible due to levee construction (Figure 2.4.1-2) (Herbold et al. 2018). Those dynamic shallow water habitats that historically provided food rich areas for rearing salmonids have been almost entirely replaced by urban and agricultural landscapes (Herbold et al. 2018). Given that juvenile salmon grow faster when they have access to inundated floodplain habitat than in adjacent river channels (Sommer et al. 2001b, Jeffres et al. 2008), it is likely that overall salmonid productivity has been diminished with the majority of Sacramento and San Joaquin rivers now confined by levees in all but the wettest years.

Central Valley salmonids evolved with access to a diverse suite of shallow water habitats, promoting resilience against a variable climate. Now adaptations to earlier conditions are mismatched with the current simplified river systems. Important sources of habitat diversity for juvenile salmonids in the current system are Yolo and Sutter flood bypasses, where salmonids can access food rich floodplain habitat under high flows. Still, with so little freshwater habitat now available in the Central Valley, habitat heterogeneity has decreased, and we expect salmonid population diversity and resilience has decreased (Figure 2.4.1-3), and vulnerability to climate variability and change has increased (Herbold et al. 2018).

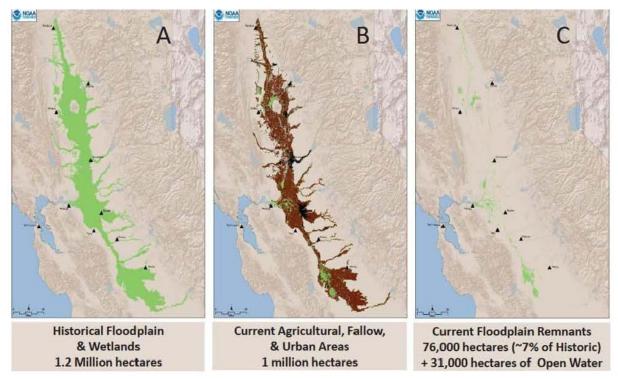


Figure 2.4.1-2 Historical floodplain and Delta wetlands habitat; (B) remnant floodplain and wetland habitat currently in agricultural lands, fallow lands, or urban areas; and (C) floodplain and wetland remnants (Herbold et al. 2018).

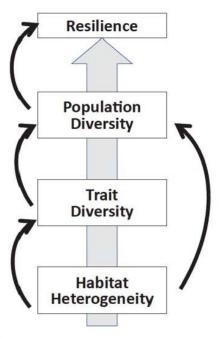


Figure 2.4.1-3 Conceptual model of how habitat heterogeneity creates trait and phenotypic diversity to promote population resilience (Herbold et al. 2018)

2.4.1.3 Water Management

Large amounts of water have historically been and currently are exported from throughout the Central Valley watershed to support agricultural, industrial, and urban demands. Upstream water diversions combined with water exports in the Delta have reduced January to June outflows by an estimated 56 percent (average), and annual outflow by an estimated 52 percent (average). In the driest condition, in certain months outflows are reduced by more than 80 percent, January to June flows are reduced by more than 70 percent and annual flows are reduced by more than 65 percent (State Water Resources Control Board 2017b).

To help put the Central Valley outflow reductions in context it is helpful to look at how other aquatic ecosystems have responded to water extractions. (Richter et al. 2012) concluded that flow modifications greater than 20 percent likely result in moderate to major changes in natural structure and ecosystem function, with greater risk associated with greater levels of alteration. Based on published studies of European and Asian rivers, Rozengurt et al. (1987) concluded that when successive spring and annual water withdrawals exceeded 30 percent and more than 40-50 percent of the normal unimpaired flow respectively, water quality and fishery resources in the river and estuary ecosystems deteriorated to levels which overrode the ability of the system to restore itself. In the context of Richter et al. (2012) and Rozengurt et al. (1987), it is not surprising that native fish and wildlife in the Bay-Delta watershed have been significantly impacted by removing over half of the water. Water diversions and the corresponding reduction in flows are not the only factor contributing to Central Valley anadromous fish species declines, but they are a significant one (State Water Resources Control Board 2017b).

The CVP/SWP is one of the world's largest water storage and conveyance systems with both the federal and the state portions of the projects capable of storing and exporting millions of acre-

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feet of water away from the Delta each year (Figure 2.4.1-4). The large volumes being exported combined with the location of the pumps in the south Delta result in significantly modified hydrologic (Figure 2.4.1-5) and biological systems (Cummins et al. 2008). The Delta also has been physically modified with development of the CVP/SWP. The Public Policy Institute of California summarized the changes and resultant impact on native fish as follows:

"After the SWP began operations in the late 1960s, the combined effects of CVP and SWP impoundments and diversions—along with those of hundreds of other water users—became clearly apparent. River flows and water quality declined, threatening both economic and environmental uses; and the ecological balance of the Delta became disastrous to native fish species (Lund et al. 2007, Moyle and Bennett 2008, Lund et al. 2010). The conversion of the 700,000-acre tidal freshwater marsh to a network of rock-lined channels had severely limited available habitat for fish, and dramatic reductions in the quantity and quality of Delta inflows further degraded that habitat. As the SWP increased its exports in the 1980s—almost doubling direct extractions from the Delta—conditions reached a crisis point (Figure 1.4)" (Figure 2.4.1-6) (Hanak et al. 2011).

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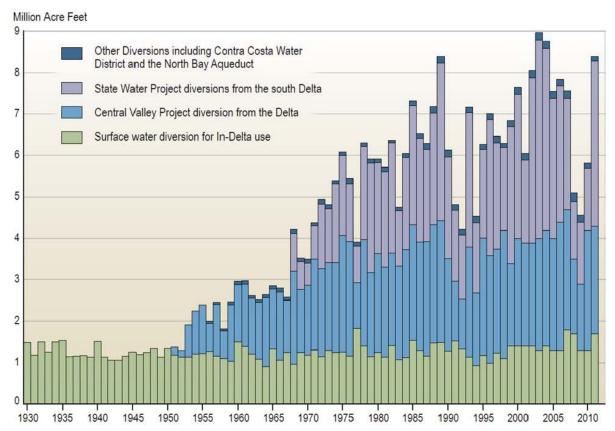


Figure 2.4.1-4 Annual Water Diversions from within the Delta (California Department of Water Resources 2013).

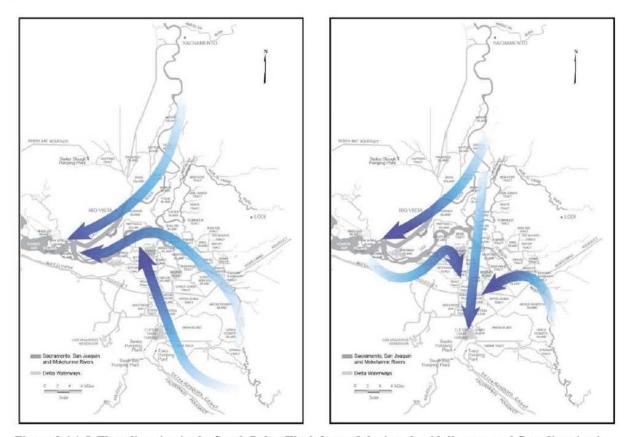
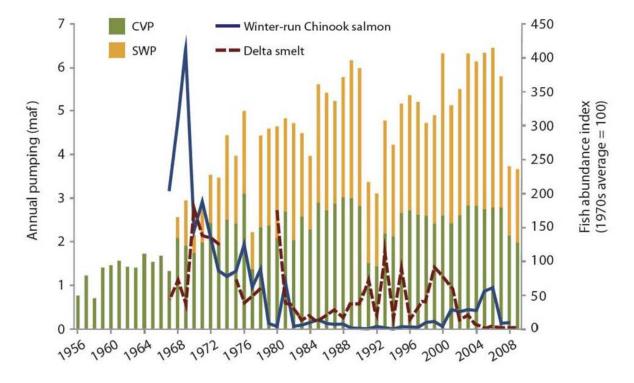


Figure 2.4.1-5 Flow direction in the South Delta. The left panel depicts the tidally averaged flow direction in the absence of export pumping. The right panel depicts reversal of tidally averaged flows that occurs during times of high exports (pumping) and low inflows to the Delta (Delta Stewardship Council 2013).



SOURCES: For Delta exports, California Department of Water Resources Dayflow data; for fish populations, California Department of Fish and Game survey data.

NOTES: Both the CVP and the SWP pump water from the southwestern Delta. CVP exports include pumping from the Contra Costa Water District, which draws from the Contra Costa Canal in the western Delta (roughly 120,000 acre-feet [af] in the 2000s), and SWP exports include pumping from the North Bay Aqueduct, which draws from the northern Delta to supply Solano and Napa Counties (roughly 50,000 af in the 2000s). Series for salmon and adult delta smelt are not available before the years shown.

Figure 2.4.1-6 Native Delta fish populations declined as exports increased (Hanak et al. 2011).

Past and current operations of the CVP/SWP, including flow releases and water temperatures, have reduced survival of juvenile salmonids outmigrating through the Delta. Prior to the protections established by the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), mortality of winter-run juveniles entering the interior of the Delta (through DCC or Georgiana Slough) was estimated to be approximately 66 percent, with a range of 35-90 percent mortality (Burau et al. 2007, Perry and Skalski 2008, Vogel 2008). Studies indicate overall mortality through the Delta for late fall-run Chinook salmon releases near Sacramento from 2006 through 2010 ranged from 46 to 83 percent (Perry et al. 2016). The available studies are consistent in that mortality is considerably higher through the central and south Delta than if the juveniles stayed within the mainstem Sacramento River.

The operation of the Delta Cross Channel gates can negatively impact migration of sDPS green sturgeon as well by providing false migration cues for juvenile and adult sturgeon to move from the lower Sacramento River to the central Delta rather than their intended destination of the western Delta and San Francisco Bay (National Marine Fisheries Service 2018g). Green sturgeon are also highly vulnerable to entrainment in the diversions of the Sacramento River and Delta;

flow and pipe configuration affects entrainment rates (Mussen et al. 2014a, Poletto et al. 2014). Efforts to salvage green sturgeon at the CVP/SWP have been conducted for decades; the number of green sturgeon observed in these facilities is typically low with a few individuals per year (National Marine Fisheries Service 2018g).

Flow fluctuations from past and current Sacramento River operations management of the CVP have resulted in stranding of juvenile salmonids, Chinook salmon redd dewatering and redd scour in the Sacramento River. High flows have also resulted in CCV steelhead redd scour on the American River but the frequency of redd scouring flows are expected to be slightly lower with completion of the Folsom Dam and Lake Water Control Manuel (National Marine Fisheries Service 2018e).

2.4.1.4 Gold Mining

The first major anthropogenic impact on the Central Valley watersheds came from hydraulic mining in the years shortly after the California gold rush began in 1848. By 1859, an estimated 5,000 miles of mining flumes and canals diverted streams used by salmonids and sturgeon for spawning and nursery habitat. Habitat alteration and destruction also resulted from the use of hydraulic cannons, and from hydraulic and gravel mining, which leveled hillsides and sluiced an estimated 1.5 billion cubic yards of debris into the streams and rivers of the Central Valley (Lufkin 1991). Mining practices profoundly altered landscape form and process: streams were dammed, diverted or drained; soil and vegetation was stripped over large areas; piles of coarse mine tailings reduced floodplain inundation; and excessive sediment loading massively aggraded and armored stream channels. Many of these impacts persist today, with severe and enduring effects on critical habitat for salmon species (National Marine Fisheries Service 2014b), and for green sturgeon (National Marine Fisheries Service 2018g).

2.4.1.5 Climate Change

One major factor affecting the range-wide status of the threatened and endangered anadromous fish in the Central Valley and aquatic habitat at large is climate change.

From 2012 to 2016, California experienced the most extreme drought since instrumental records began in 1895. A growing body of evidence suggests that climate change has increased the likelihood of extreme droughts in California (Department of Water Resources 2018).

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen et al. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991, Dettinger et al. 2004). Specifically, the Sacramento River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1987, Roos 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph, and strain the ability of reservoir water managers to provide cold water releases for salmonids.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. Large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature

increases that rapidly melt spring snowpack (Vanrheenen et al. 2004). Factors modeled by Vanrheenen et al. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100 percent in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (Vanrheenen et al. 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is shallower than in the San Joaquin River watersheds to the south.

Warming attributed to climate change is expected to affect Central Valley anadromous salmonids and green sturgeon more than it already has. Because the Central Valley salmon, steelhead, and green sturgeon runs are restricted to low elevations as a result of impassable dams, if climate warms by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon, and green sturgeon populations can persist (Williams 2006, National Marine Fisheries Service 2018g). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951–1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the Central Valley are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats can support salmonid life stages. Projected 33 percent salinity increases in the Sacramento River Basin in the 21st century due to climate change may result in declining habitat quality and food web productivity; climate change will alter the salinity and prey base in green sturgeon juvenile rearing habitat and adult migration corridors (CH2M HILL 2014, National Marine Fisheries Service 2018g).

2.4.2 Other Factors Affecting Listed Fish Species and Critical Habitat in the Action Area

2.4.2.1 Hatcheries

Hatchery management was identified as an important factor contributing to the listings of CV spring-run Chinook salmon and CCV steelhead (National Marine Fisheries Service 2014b). Most of California's anadromous fish hatcheries were constructed for mitigation purposes related to loss of habitat due to construction of hydroelectric dams and both SWP and CVP management, and are therefore part of the environmental baseline. Statewide, there are nine hatchery facilities operated by the CDFW and two hatchery facilities operated by the USFWS. California's anadromous fish hatcheries produce ESA-listed Chinook salmon (Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon) and CCV steelhead. However, production of non-listed Central Valley fall-run Chinook salmon is the largest contributor of hatchery-origin Chinook salmon in the state, with a total combined release of nearly 30 million smolts annually.

In the Central Valley, LSNFH, CNFH, FRFH, Nimbus Fish Hatchery, and Mokelumne Fish Hatchery currently produce Chinook salmon and all of them except for LSNFH also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to natural-origin Chinook salmon populations through genetic impacts, displacement, competition for food and other resources, predation of hatchery fish on natural-origin fish, and increased fishing pressure on natural-origin stocks as a result of hatchery production (Waples 1991). The relatively low number of adult spawners needed to sustain a hatchery population can result in high harvest-to-escapement ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of natural-origin populations existing

in the same system as hatchery populations due to incidental bycatch (McEwan 2001). Currently, hatchery produced fall-run Chinook salmon comprise the majority of fall-run adults returning to Central Valley streams. Hatcheries in the Central Valley follow a 25 percent constant fractional marking of hatchery produced fall-run Chinook salmon juveniles. Any returning populations with adipose fin-clipped adult escapement greater than 25 percent, would indicate that hatchery-produced fish are the predominate source in those spawning populations.

To maximize survival, and as a result of the degraded conditions of downstream migration corridors in the Central Valley, most Chinook salmon hatchery production has been routinely released off-site, significantly downstream of the hatchery or in the estuary. The exception is CNFH, where hatchery managers have consistently implemented in-river releases. This approach was temporarily suspended during the recent drought (2014 and 2015), when environmental conditions in Battle Creek and the upper Sacramento River were likely to result in adverse impacts and significant mortality. In order to circumvent these unfavorable conditions, the majority of the Chinook salmon produced by CNFH and other Central Valley hatcheries were trucked and released offsite. Although this offsite release practice has improved survival rates and resulted in increased ocean harvest of hatchery fish, it has also led to widespread straying of hatchery fish throughout the Sacramento-San Joaquin system (California Hatchery Scientific Review Group 2012). The impacts of artificial propagation programs in the Central Valley are primarily genetic impacts due to straying of hatchery fish and the subsequent interbreeding of hatchery fish with natural-origin fish. Effects of the continuation of producing and releasing salmonids at these hatcheries are considered part of the environmental baseline.

Introgression of spring- and fall-run Chinook salmon and significant straying of adults from FRFH have posed a significant threat to the genetic integrity of natural spawning fall- and spring-run Chinook salmon in other watersheds, such as the upper Sacramento River and associated tributaries (National Marine Fisheries Service 2014b). The management of hatcheries, such as Nimbus Fish Hatchery and FRFH, can directly impact Chinook salmon and steelhead populations by oversaturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to the inability to spatially separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River.

Over the past several decades, the genetic integrity of CCV steelhead has diminished by increases in the proportion of hatchery fish relative to naturally produced fish, use of out-of-basin stocks for hatchery production, and straying of hatchery produced fish (National Marine Fisheries Service 2014b). Potential threats to natural-origin steelhead from hatchery programs include: (1) mortality in fisheries targeting hatchery-origin fish; (2) competition for prey and habitat; (3) predation by hatchery-origin fish; (4) disease transmission; and (5) genetic introgression by hatchery-origin fish that spawn naturally and interbreed with local natural-origin populations (National Marine Fisheries Service 2016b, d).

High densities of hatchery fish in some rivers may cause competition with natural-origin juvenile parr and smolts. This problem is likely to be greatest when hatchery smolts residualize (those that do not migrate to the ocean). How often this occurs in Central Valley rivers is unknown. What is known is that some hatchery smolts do stray into other rivers. For example, hatchery smolts have been documented in the Vaki Riverwatcher camera, moving upstream/downstream

of Daguerre Point Dam on the Yuba River, which most likely originated from the FRFH. They do not appear to be residualizing upstream of the dam, as they do not remain upstream of the dam for long, based on Vaki counts and anecdotal information from angling and snorkel surveys, but their behavior below the dam is not tracked. In the lower American River, some hatchery smolts appear to become "half-pounders", but it is unknown how much time they spend in the river versus in the Delta or Bays. Recent evaluations of these hatchery programs and Hatchery Genetic Management Plans have proposed or recommended changes in hatchery policies and management to address these impacts (State Water Resources Control Board 2017b).

Hatcheries may also have short-term positive effects through supporting listed salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally-spawning fish in the short-term under specific scenarios. Artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally spawned populations at critically low abundance levels. For example, LSNFH propagates winter-run Chinook salmon to conserve the genetic resources of a single fish population at low abundance and in danger of extinction. A potential complementary goal of the hatchery program is restoration of the ESU. This goal could be achieved by providing a source of winter-run Chinook salmon to re-establish naturally spawning populations in historical habitats. According to the Central Valley salmonid recovery plan (National Marine Fisheries Service 2014b), "The LSNFH winter-run Chinook salmon conservation program on the upper Sacramento River is one of the most important reasons that Sacramento River winter-run Chinook salmon still persist." Conservation hatcheries like LSNFH can contribute to the recovery of listed species. However, it is important to note that relative abundance is only one component of a viable salmonid population and managers must also consider the possible adverse impacts of hatchery influence in the long-run, such as reduced fitness of the population.

As described in Appendix C the USFWS has been engaged in efforts regarding CNFH and LSNFH and their contribution to the management and restoration of Chinook salmon in the Sacramento River and Battle Creek. These efforts are: (1) improving LSNFH; (2) implementing the Battle Creek Reintroduction Plan; (3) designing and fish trapping and sorting facility at CNFH; and (4) studying alternative release strategies for CNFH produced fall-run Chinook salmon. Appendix C includes a brief description of each effort, including progress to date and expectations for completion and funding. All of these efforts are underway and at least partially funded, with most of the funding provided by Reclamation with additional funding and support from other partners.

Specific recent and ongoing actions for improving the LSNFH include:

 During the drought in 2014 and 2015, and at the request of NMFS and CDFW, LSNFH increased production of winter-run Chinook salmon to compensate for expected high temperature-dependent mortality in the Sacramento River and reinstated the captive broodstock program. Also, Reclamation funded the rental of two commercial-size chillers to ensure adequate water temperatures for adult holding, egg incubation, and juvenile rearing. Those chillers were rented during the summer and fall and used on a just few occasions. Subsequently Reclamation has funded a small permanent chiller to ensure temperatures for egg incubation only.

- Several years ago, Reclamation funded, and the USFWS operated the ACID trap, a fish trap on the north side of the Sacramento River at Caldwell Park. To date, only two salmon have been collected at that site and the USFWS ceased operating the trap this year.
- 3. The USFWS partners with the CDFW for much of the monitoring for winter-run Chinook salmon on the Sacramento River. USFWS efforts include coded-wire tagging and marking Livingston Stone NFH-produced winter-run Chinook salmon, acoustic tagging a subset of those fish, rotary screw trapping at Red Bluff Diversion Dam, and carcass surveys on the mainstem Sacramento River. Reclamation covers the costs for all of USFWS efforts, mostly out of the operational funding agreement for CNFH and LNFH and the Opinion monitoring agreement with the USFWS' Red Bluff Fish and Wildlife Office. Both of these are long-term agreements with a history of renewal.

Specific ongoing actions for improving the implementing the Battle Creek Reintroduction Plan include:

1. In 2017, LSNFH had excess winter-run Chinook salmon broodstock on station. This occurred because extra captive broodstock were being kept in the event additional fish were needed to supplement the mainstem Sacramento River program because of drought conditions. The extra captive broodstock were not needed for the Sacramento program and the agencies decided to use those fish to produce juveniles for release into Battle Creek to jumpstart the reintroduction of winter-run Chinook salmon in advance of the implementation of the Battle Creek Reintroduction Plan and the complete restoration of Battle Creek. In the spring of 2018, CNFH released 215,000 juvenile winter-run Chinook salmon into upper Battle Creek. Subsequently, the agencies decided to continue this jumpstart program and CNFH has integrated the production of approximately 200,000 winter-run Chinook salmon juveniles into its annual operations. This currently involves spawning broodstock and rearing eggs at LSNFH, then transferring fry to CNFH for further rearing and release.

Specific ongoing actions for constructing a fish trapping and sorting facility at CNFH include:

1. The USFWS assembled a multi-agency team to design a fish trapping and sorting facility at the CNFH Weir to minimize handling and migration delay of listed species during CNFH's fall-run Chinook spawning operations, and to allow for passage, monitoring, and management of fish passage during times when spawning operations are not taking place. The project is currently envisioned to be constructed in two phases, with the first phase establishing the ability to pass fish through the fish sorting facility year round, which would allow for monitoring and management during times when the spawning operations are not being conducted. The second phase would allow for selective bypassing of the spawning building during spawning operations and automation of many of the processes. To date, with Reclamation funding and input from partner agencies, the USFWS has completed 65 percent design of Phase 1, with anticipated 100 percent design completion in August, 2019.

Specific ongoing actions for studying alternative release strategies for CNFH produced fall-run Chinook salmon include:

Evaluation of alternative release strategies for CNFH fall-run Chinook salmon to
determine if trucking to an alternative release site can increase juvenile survival to
the ocean and adult returns to the Sacramento River without unacceptable levels of
straying. To date, the USFWS has implemented one year of a three-year study,
largely through the use of CNFH operational funds, acoustic tags provided by
Reclamation, tag surgeries provided by U.C. Davis, and net pen operations provided
by stakeholders and the CDFW's Mokelumne River Hatchery. The current plan is to
run the study for another two years.

2.4.2.2 Harvest

The following discussions of harvest impacts for winter-run and spring-run Chinook salmon, and steelhead were, in large part, taken from the most recent NMFS 5-year status review reports for each species (National Marine Fisheries Service 2016c, b, a).

2.4.2.2.1 Winter-run Chinook salmon

2.4.2.2.1.1 Ocean Harvest Impacts

Winter-run Chinook salmon have a more southerly ocean distribution relative to other California Chinook salmon stocks, and are primarily impacted by fisheries south of Point Arena, California. Winter-run Chinook salmon age-3 ocean fishery impact rate estimates for the region south of Point Arena (an approximation of the exploitation rate) are currently available for 2000–2017, and have remained relatively stable over this period, averaging 16 percent. Fisheries in 2008 and 2009 were closed south of Point Arena owing to the collapse of the Sacramento River fall-run Chinook salmon stock and insufficient data (i.e., insufficient coded-wire tag recoveries) exist for estimating a winter-run Chinook salmon impact rate in 2010. If years 2008-2010 are omitted, the average age-3 impact rate is 18 percent (Pacific Fishery Management Council 2019).

There have been several layers of ocean salmon fishery regulations implemented to protect winter-run Chinook salmon beginning in the early 1990s. For example, a substantial portion of the winter-run Chinook salmon ocean harvest impacts used to occur in February and March recreational fisheries south of Point Arena, but fisheries at that time of the year have been closed since the early 2000s. In general, under the provisions of the Opinions issued since 2004 (National Marine Fisheries Service 2018c), ocean salmon fishing remains closed from late fall through April for the commercial fishery and March for the recreational fishery and sector specific size limits are in place as additional protective measures.

O'Farrell and Satterthwaite (2015) hind casted winter-run Chinook salmon age-3 ocean impact rates back to 1978, extending the impact rate time series beyond the range of years where direct estimation is possible (2000-2013). Their results suggest that there were substantial reductions in ocean impact rates prior to 2000 and that the highest impact rates occurred in a period between the mid-1980s and late-1990s.

NMFS has completed several ESA consultations regarding the impacts of the ocean salmon fishery on winter-run Chinook salmon. The most recent and currently applicable Opinion was

completed in March 2018. That Opinion analyzed a proposed new abundance-based control. The harvest control rule specifies the maximum allowable age-3 impact rate on the basis of a forecast of the Sacramento River winter-run Chinook salmon age-3 escapement in the absence of fisheries. The limits to the impact rate imposed by the harvest control rule is an additional control on ocean fisheries which still includes previously existing constraints on fishery opening and closing dates and minimum size limits south of Point Arena. From 2012 to 2019, the winter-run Chinook salmon harvest control rule has specified maximum allowable forecast impact rates ranging from 12.9 percent to 19.9 percent (Pacific Fishery Management Council 2019).

2.4.2.2.1.2 Freshwater Angling Impacts

What little winter-run Chinook salmon freshwater harvest that existed historically was essentially eliminated beginning in 2002, when Sacramento Basin Chinook salmon fishery season openings were adjusted so that there would be little temporal overlap with the winter-run Chinook salmon spawning migration and spawning period. However, early arriving fish may still be harvested prior to January 1. Additionally, higher densities of fish in this portion of the river may lead to higher early harvest rates. Higher densities of fish, particularly below dams, likely create opportunities for both illegal poaching of salmon and the inadvertent or intentional snagging of fish. In addition, the upper Sacramento River supports substantial angling pressure for rainbow trout. Rainbow trout fishers tend to concentrate in locations and at times where winter-run Chinook salmon are actively spawning (and therefore concentrated and more susceptible to impacts). By law, any winter-run Chinook salmon inadvertently hooked in this section of river must be released without removing it from the water. However, winter-run Chinook salmon are impacted as a result of disturbance and the process of hook-and-release. In addition, because the taking of salmon is permitted after August 1, some late spawning winter-run Chinook salmon may be taken.

2.4.2.2.2 Spring-run Chinook Salmon

2.4.2.2.2.1 Ocean Harvest Impacts

The available information indicates that the fishery impacts on the CV spring-run Chinook salmon ESU have not changed appreciably since the 2010 status review (National Marine Fisheries Service 2016a). Attempts have been made (Grover et al. 2004) to estimate CV springrun Chinook salmon ocean fishery exploitation rates by capturing and tagging natural-origin spring-run Chinook salmon from Butte Creek, but due to the low number of coded-wire tag recoveries, the uncertainty of these estimates is too high for them to be of value. CV spring-run Chinook salmon have a relatively broad ocean distribution from central California to Cape Falcon, Oregon, that is similar to that of Sacramento River fall-run Chinook salmon, thus trends in the fall-run Chinook salmon ocean harvest rate are thought to provide a reasonable proxy for trends in the CV spring-run Chinook salmon ocean harvest rate. While the fall-run Chinook salmon ocean harvest rate can provide information on trends in CV spring-run Chinook salmon fishing mortality, it is likely that CV spring-run Chinook salmon experience lower overall fishing mortality. If maturation rates are similar between CV spring-run and fall-run Chinook salmon, the ocean exploitation rate on CV spring-run Chinook salmon would be lower than fall-run Chinook salmon in the last year of life because CV spring-run Chinook salmon escape ocean fisheries in the spring, prior to the most extensive ocean salmon fisheries in summer.

The fall-run Chinook salmon ocean harvest rate index peaked in the late 1980s and early 1990s, but then declined. With the closure of nearly all Chinook ocean fisheries south of Cape Falcon in 2008 and 2009, the index dropped to 6 percent and 1 percent respectively. While ocean fisheries resumed in 2010, commercial fishing opportunity was severely constrained, particularly off California, resulting in a harvest rate index of 16 percent. Since 2011, ocean salmon fisheries in California and Oregon have had more typical levels of fishing opportunity. The average Central Valley fall-run Chinook salmon ocean harvest rate from 2011 to 2018 was 46 percent, which is generally similar to levels observed from the late 1990s to 2007. In addition, NMFS determined that the management framework for Sacramento winter-run Chinook that includes the updated harvest control rule and size and season limits contains equivalent and/or additional restrictions on the fishery compared to previous management measures and is more responsive than prior management frameworks to information related to the status of CV spring-run Chinook salmon by accounting for changes in freshwater conditions in the Central Valley for Sacramento River winter-run Chinook salmon. The CV spring-run Chinook salmon spawning migration largely concludes before the mid- to late-summer opening of freshwater salmon fisheries in the Sacramento Basin, and salmon fishing is prohibited altogether on Butte, Deer, and Mill creeks, suggesting in-river fishery impacts on CV spring-run Chinook salmon are relatively minor. Overall, it is highly unlikely that harvest resulted in overutilization of this ESU (National Marine Fisheries Service 2016a).

2.4.2.2.3 Steelhead

In an attempt to minimize potential negative behavioral and genetic interactions with naturalorigin steelhead, CDFW has increased the bag limit for hatchery steelhead on several popular rivers in the Central Valley. Following is a chronological rundown of changes in daily bag and possession limits that have occurred since March 1, 2010, which was the effective date of the 2010-2011 regulations cycle:

- Prior to March 1, 2010, the daily bag and possession limit in the Sacramento River system, including the lower Mokelumne River, was one steelhead in the bag and one in possession.
- Effective March 1, 2010, the steelhead daily bag and possession limit on the mainstem Sacramento and American Rivers increased to a daily bag of two hatchery steelhead and a possession limit of four hatchery steelhead. On the Feather and Mokelumne rivers, the daily bag and possession limit remained at one hatchery steelhead in the bag, and one hatchery steelhead in possession.
- On March 1, 2013, the steelhead daily bag and possession limit on the Feather River increased to two and four hatchery steelhead, respectively.
- In the current regulations cycle with an effective date of March 1, 2016, the steelhead daily bag and possession limit remains at two and four, respectively, on the Sacramento, American, and Feather rivers; and at one and one, respectively, on the Mokelumne River.

The 2012-2016 drought conditions affected some steelhead fishing opportunities for this DPS. For example, the California Fish and Game Commission imposed an emergency fishery closure on the American River during February of 2014. The closure ended in April of that year.

The regulation changes reviewed above for steelhead fishing in the Central Valley suggest that there is the potential for a change in harvest dynamic over the past several years. The overall

trend has been to incrementally increase the opportunity for harvest of hatchery-origin steelhead by increasing the daily bag and possession limits. The rationale behind encouraging more harvest of hatchery-origin steelhead is to minimize potential negative behavioral and genetic interactions with natural-origin steelhead. In addition, retention of hatchery-origin steelhead in the Central Valley is typically very low. Yet, the purpose of the hatchery programs is to provide a harvestable fishery resource. Thus, CDFW would like to see more of that resource utilized for its intended consumptive purpose.

CDFW performs angler surveys on Central Valley streams, and data from these surveys are used to estimate steelhead harvest and fishing effort. However, these estimates do not appear to be regularly reported. Available data on angler retention of hatchery-origin steelhead suggest an increase in retention since the 2010-2011 regulatory cycle (California Department of Fish and Wildlife 2016d). Mean retention from 2007-2008 through 2009-2010 was 13.1 percent, while mean retention from 2010-2011 through 2015-2016 was 20.4 percent. These means do not differ significantly, however (2-tailed t-test: t = -1.82, p = 0.11; no significant departure from normality in sample data; variances not significantly different). This analysis may possibly be improved by using expanded catch and retention data for each regulatory year (National Marine Fisheries Service 2016b). Steelhead are rarely caught in ocean fisheries and retention of steelhead in non-treaty commercial ocean fisheries is currently prohibited.

2.4.2.2.4 Green Sturgeon

Starting in 2006, green sturgeon harvest was prohibited by CDFW. California has established specific rules to protect sDPS green sturgeon, prohibiting fishing for green or white sturgeon year-round in the mainstem Sacramento River from Highway 162 (RK 283) to Keswick Dam (RK 485) and Yolo Bypass, prohibiting the removal of incidentally hooked green sturgeon from the water, only allowing the use of barbless hooks, prohibiting use of wire leaders and snares, and increasing fines for poaching (National Marine Fisheries Service 2018g).

2.4.2.3 Water Quality

Current land use in the Sacramento River basin and Delta has seen a dramatic increase in urbanization, industrial activity, and agriculture in the last century. In a Sacramento River Basin-wide study, areas with relatively high concentrations of agricultural activity as well as areas that had previously experienced mining activity showed increased concentrations of dissolved solids and nitrite plus nitrate (Domagalski et al. 2000). Domagalski et al. (2000) also found varying concentrations of mercury and methylmercury throughout the Sacramento River Basin. Concentrations of these contaminants were greatest downstream of previous mining sites (primarily Cache Creek). Both studies showed lower concentrations of contaminants in the American River as compared to other sites sampled in the Sacramento River Basin.

Multiple studies have documented high levels of contaminants in the Delta such as Polychlorinated biphenyls (PCBs), organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), selenium, and mercury, among others (Stewart et al. 2004, Leatherbarrow et al. 2005, Brooks et al. 2012), suggesting that fish are exposed to them. However, the inability to characterize concentrations and loading dynamics makes it difficult to quantify transport and total contaminant loading in the system (Johnson et al. 2010). Additionally, numerous discharges of treated wastewater from sanitation wastewater treatment plants (e.g., Cities of Tracy,

Stockton, Manteca, Lathrop, Modesto, Turlock, Riverbank, Oakdale, Ripon, Mountain House, and the Town of Discovery Bay) and the untreated discharge of numerous agricultural wasteways are emptied into the waters of the San Joaquin River and the channels of the south Delta (National Marine Fisheries Service 2014b). This leads to cumulative additions to the system of thermal effluent loads as well as cumulative loads of potential contaminants (i.e., selenium, boron, endocrine disruptors, pesticides, biostimulatory compounds, etc.).

Harmful algal blooms also occur in the Delta and, although toxic exposure of estuarine fish has been documented, the extent of their impacts to the aquatic food web is unknown (Lehman et al. 2010). More recently, concerns have been raised about ammonia levels in the Delta (Davis et al. 2018). Central Valley Regional Water Quality Control Board (CVRWQCB) is working with researchers at San Francisco State University and University of California, Davis, to evaluate the impact of ammonia in the Delta (Connon et al. 2011). All of the waters within the Delta are listed as impaired by at least one factor, either due to the presence of unacceptable levels of pollutants or lack of maintaining conditions such as adequate dissolved oxygen levels (U.S. Environmental Protection Agency 2011b).

Pesticides are found in the water and bottom sediments throughout the Delta. The more persistent chlorinated hydrocarbon pesticides are consistently found at higher levels than the less persistent organophosphate compounds. Sediments in the western Delta have the highest pesticide content. Pesticides have concentrated in aquatic life, but long-term effects and the effects of intermittent exposure are not known (National Marine Fisheries Service 2018b). There are now concerns about the aquatic toxicity of pyrethroid-based pesticides (bifenthrin, cyfluthrin, cypermethrin, and permethrin), which have replaced organophosphorus pesticides such as diazinon and chlorpyrifos. Little is known about the potential for interactive toxicity from complex pesticide mixtures and/or pesticides interacting with other chemical, physical, or biological stressors (U.S. Environmental Protection Agency 2011a). However, pesticide use for the treatment and elimination of invasive aquatic vegetation may have important consequences for water quality parameters including: amount of light that reaches the water column, temperature, salinity, turbidity, and food availability, which may also influence the migratory paths that green sturgeon salmonids utilize in the Delta (National Marine Fisheries Service 2018g).

In December of 2018, the State Water Board updated the Bay-Delta Plan to protect beneficial uses in the Bay-Delta watershed. Phase I of this work involved updating San Joaquin River flow and southern Delta water quality requirements included in the Bay-Delta Plan (State Water Resources Control Board 2018). The Environmental Protection Agency (EPA) developed an action plan in 2012 to address water quality concerns in the Delta (U.S. Environmental Protection Agency 2012). This plan included the following actions: (1) Strengthen estuarine habitat protection standards, (2) Advance regional water quality monitoring and assessment, (3) Accelerate water quality restoration through Total Maximum Daily Loads, (4) Strengthen selenium water quality criteria, (5) Prevent pesticide pollution, (6) Restore aquatic habitats while managing methylmercury, and (7) Support the Bay Delta Conservation Plan.

2.4.2.4 Water Temperature Management

The environmental baseline considers observed temperature related mortality from the past to the present, including temperature dependent mortality and other mortality factors in the Upper

Sacramento River. Historical context can be found in the WOA scenario which highlights Reclamation's past actions to manage cold water and insert the temperature control device in Shasta Reservoir. Most recent past exposures include the effects of drought, operations and temperatures on very high mortality of natural winter-run Chinook salmon production in 2014 and 2015.

Sacramento River – NMFS' 2009 Opinion required, through Reasonable and Prudent Alternative (RPA) actions, seasonal operations and summer water temperature management to provide cold water habitat for early life stages of winter-run and CV spring-run Chinook salmon each year (National Marine Fisheries Service 2009b).

On August 2, 2016, Reclamation requested using the adaptive management provision in the NMFS 2009 Opinion related to Shasta Reservoir operations. The basis for this request included recent, multiple years of drought conditions, new science and modeling, and data demonstrating the low population levels of endangered winter-run Chinook salmon and threatened CV springrun Chinook salmon. NMFS, in consultation with Reclamation, developed a draft proposed amendment to the NMFS' 2011 amendment to the 2009 RPA (National Marine Fisheries Service 2017d). As described in the January 19, 2017, cover letter, NMFS expected the Shasta RPA amendment as a necessary bridge to and part of a phased approach that will inform the ROC on LTO. The draft proposed amendment included a pilot approach to water temperature management that would be implemented starting in 2017. The 2017 pilot approach applied new science on the thermal tolerance of Chinook salmon eggs (Martin et al. 2016) and was designed to efficiently utilize Shasta Reservoir's limited supply of cold water by basing the spatial distribution of protective temperatures on the within-season spatial distribution of winter-run Chinook salmon redds. The intent was to provide daily average water temperatures of 53°F or less to the furthest downstream redds. The existing RPA requirement was a daily average temperature of 56°F or less at compliance locations between Balls Ferry and Bend Bridge, which are not based on the within-season redd distribution. Although the Shasta RPA amendment was not finalized, the science-based, within season management under the 2017 pilot approach, along with one of the wettest years on record (in water year 2017), resulted in 44 percent egg-to-fry survival, one of the highest estimates on record. The pilot approach was implemented in 2018 and will also be implemented in 2019. Hamda et al. (2019) recently modeled the effects of Sacramento River water-temperature management for listed spring-run and winter-run Chinook salmon eggs on the growth rate of juvenile green sturgeon, and there was relatively little impact on the growth rate of the species.

Clear Creek - RPA Action I.1.5 Thermal Stress Reduction - requires Reclamation to reduce thermal stress to over-summering CCV steelhead and CV spring-run Chinook salmon during holding, spawning, and embryo incubation by managing Whiskeytown releases to meet a daily water temperature of (1) 60°F at the IGO gage from June 1 through September 15, and (2) 56°F at the IGO gage from September 15 to October 31. Reclamation has operated releases for temperature management since implementation of the RPA action, though criteria was not met in some years (see Section 2.5.3.4.1 Clear Creek Temperature Management, that describes effects of higher water temperatures on CV spring-run Chinook salmon adult holding and spawning, as the PA is the same as current operations in the environmental baseline). The RPA also requires Reclamation, in coordination with NMFS, to assess improvements to modeling water temperatures in Clear Creek and identify a schedule for making improvements. In the NMFS, 2011 amendment to the NMFS 2009 Opinion, the need to "explore options to avoid non-

compliance with the RPA" was specified for this action. To date, an assessment of and schedule for making improvements to modeling water temperatures in Clear Creek has not been completed. However, beginning in late 2016, Reclamation initiated a temperature model development process, focused on developing a model for Shasta and Keswick reservoirs, with future plans to expand the model to the Trinity Division.

RPA Action I.1.4 Spring Creek Temperature Control Curtain - required Reclamation to replace the Spring Creek Temperature Control Curtain in Whiskeytown Lake by 2011, with the objective to reduce adverse impacts of project operations on water temperature for listed salmonids in the Sacramento River. The curtain was replaced in 2011. In addition, the Oak Bottom Temperature Control Curtain, which is located at the upper end of Whiskeytown Reservoir and intended to enhance coldwater transport from the upper end of the reservoir to the lower reservoir outlets, including Spring Creek Tunnel and Whiskeytown Dam, was replaced in May of 2016. Having both temperature curtains functioning together in tandem enhance cold-water availability in the Spring Creek Tunnel and Whiskeytown Dam outlets, and Reclamation's Technical Service Center is currently evaluating their performance, with a final report expected in 2019.

American River - RPA action II.3 in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b) requires Reclamation to implement physical and structural modifications to the American River Division of the CVP in order to improve water temperature management. The purpose of these physical and structural modifications are to facilitate more control over temperature and amount of water releases into the American River for spawning Chinook salmon and steelhead, and migrating and rearing juveniles of both species. Implementation has been delayed, but Reclamation has indicated that some work is being done on the temperature control device at Folsom Dam (http://deltacouncil.ca.gov/science-program/2018-long-term-operations-biologicalopinions-lobo-annual-reports). In addition, annual water temperature management plans for the lower American River have been developed annually starting in 2010. An Iterative Coldwater Pool Management Model was developed by Reclamation in 2010 and is being used annually to evaluate coldwater pool availability in Folsom Reservoir and develop water temperature objectives in the lower American River that are as protective as possible for salmonids. Despite these efforts, current water temperatures in the lower American are annually stressful for juvenile steelhead rearing over the summer and fall-run Chinook salmon adults returning to spawn (see Section 2.5.4.1.2 Juvenile Rearing, and especially Figure 2.5.4-8 on historical water temperatures and effects on juvenile CCV steelhead rearing).

2.4.2.5 Diversions and Entrainment

There are over 3,700 water diversions on the Sacramento and San Joaquin rivers, their tributaries, and in the Delta; most of these are unscreened (Mussen et al. 2013), posing a widespread threat to early life stages of fish. A study of 12 unscreened, small to moderate sized diversions (< 150 cfs) in the Sacramento River, found that diversion entrainment was low for listed salmonids and sturgeon, though the study points out that the diversions used were all situated relatively deep in the river channel (Vogel 2013). The study also suggested that the factors affecting fish entrainment at unscreened diversions are complex and poorly understood because of the many site-specific variables that influence the exposure and vulnerability of fish to entrainment (Vogel 2013).

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In a previous mark-recapture study addressing mortality caused by unscreened diversions, Hanson (2001) observed low mortality in hatchery-produced juvenile Chinook salmon released upstream of four different diversions throughout the Sacramento River (\leq 0.1 percent of individuals released).

The CVPIA's Anadromous Fish Screen Program (AFSP) was established in 1994 to minimize the impacts of diversions on anadromous fish and provide technical guidance and cost-share funding for fish screen projects. The AFSP also supports activities and studies to assess the potential benefits of fish screening, determine the highest priority diversions for screening, improve the effectiveness and efficiency of fish screens, encourage the dissemination of information related to fish screening, and reduce the overall costs of fish screens (State Water Resources Control Board 2017b). Through AFSP, as of 2019, there have been a total of 30 fish screens constructed at diversions on the Sacramento River, 4 fish screens in the San Joaquin and tributaries, and 3 fish screens at Delta diversions, which has resulted in reduced entrainment at those diversions. Currently, screen criteria for green sturgeon has not been developed, and the benefits of projects intended to reduce salmonid impingement and entrainment at diversions to green sturgeon are not fully understood (National Marine Fisheries Service 2018g).

A NMFS Opinion on the construction of NMFS-approved, state-of-the-art fish screens at the Tehama Colusa Canal diversion included a requirement to monitor, evaluate, and adaptively manage the new fish screens to ensure the screens are working properly and impacts to listed species are minimized (National Marine Fisheries Service 2009d). We expect these actions have helped reduce entrainment of listed fish in the upper Sacramento River. In addition, the 2009 RPA included the requirement to identify and implement projects to ensure the M&T Ranch water diversion is adequately screened to protect winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. A short-term screen is currently functioning at the site and a permanent screening option is under development.

Gate operations at the RBDD (rkm 391, completed in 1964) created a migration barrier during a critical time for mature adults; operations limited access to spawning habitat for migrating spawning-capable adult green sturgeon (Poytress et al. 2015). In 2013, the RBDD was decommissioned, which permanently lifted the gates and permitted volitional passage for sDPS green sturgeon during all months of river presence (National Marine Fisheries Service 2018g). This action has had a major beneficial impact on spawning distribution for green sturgeon and possibly aided in population recovery (National Marine Fisheries Service 2018g).

2.4.2.6 Predation

Predation of juvenile salmonids and green sturgeon is thought to be a contributing factor to high mortality at this life stage (Hanson 2009, Vogel 2011, Michel et al. 2015). There have been significant alterations to aquatic habitat that are conducive to the success of non-native piscivorous fish such as creating a largely freshwater system out of the naturally estuarine, variable salinity Delta, riverbank armoring, and reduction of habitat complexity (Vogel 2011). The altered habitat and modified flow regimes have benefitted non-native striped bass, catfish, largemouth bass, and smallmouth bass, such that predation has been characterized as being, "...likely the highest source of mortality to anadromous fish in the Delta" (Vogel 2011). The 2009 RPA [RPA Action IV.4.2(2)(a)] requires DWR to implement predator control methods within CCF to reduce salmon and steelhead pre-screen loss to no more than 40 percent. DWR is

currently implementing four interim methods and conducting studies to reduce predation on listed anadromous fish species in CCF. In March 2019, DWR completed an in-depth study to evaluate dredging alternatives to reduce pre-screen loss of salmonids and sturgeon in CCF.

2.4.2.7 Physical Disturbance from Dredging and Vessel Traffic

Dredging operations periodically occur for a variety of purposes including the maintenance of shipping channels; maintenance of diversion intakes; and to remove accumulated sediments from recreational and commercial facilities such as boat docks and marinas. Dredging can have detrimental impacts to listed fish species through physical disturbance, and through the resuspension of sediment. ESA consultations are periodically conducted by NMFS for dredging projects of varying scope and scale in the Central Valley (National Marine Fisheries Service 2018a).

Select portions of the action area currently experience heavy commercial and recreational vessel traffic, creating hazards to listed fish species through both physical and acoustic disturbance. These impacts may lead to direct mortality or may induce changes in behavior that impair feeding, rearing, migration, and/or predator avoidance. The Stockton Deep Water Ship Channel (DWSC) and Sacramento DWSC experience frequent large commercial vessel traffic. The mainstem Sacramento River; American River; Delta; and remainder of Suisun, San Pablo, and San Francisco bays receive occasional commercial tugboat traffic as construction barges and other heavy equipment are transported upstream. Finally, recreational vessel traffic occurs throughout the action area. In a report on Delta boating needs through the year 2020, the California Department of Boating and Waterways stated an expected increase in boating activity in the Delta area (California Department of Boating and Waterways 2003).

2.4.2.8 Required Restoration Actions from NMFS (2009) RPA on the Long-term Operations of CVP/SWP Biological Opinion

Required restoration actions from the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b) and the associated 2011 amendments (National Marine Fisheries Service 2011d), are described below, and the status of their implementation. Additional updated information related to restoration actions are available in the Salmon Resiliency Strategy (California National Resources Agency 2017).

RPA Action I.7: Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass (Improve Yolo Bypass Adult Fish Passage)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation and DWR shall improve adult salmonid and sturgeon passage through the Yolo Bypass, including the Fremont Weir, by modifying or removing barriers. This action will include preventing straying at Wallace Weir (see Section 2.4.2.9, #6); improving several agricultural road crossings; improving Lisbon Weir; and improving the existing Fremont Weir fish ladder. This is expected to reduce migratory delays and straying of adult salmonids and sturgeon because insufficient adult fish passage at flood bypass weirs combined with attraction flows leads to stranding risk and reduced fish survival, timing, and condition. Improvements to Freemont Weir have resulted in improved fish passage in 2019. Reclamation expects to construct the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project in 2020 to comply with

the requirement in RPA Action I.7. This action is expected to result in improvements to the migration corridor, and help minimize stranding in the Yolo Bypass. Improving access to the Yolo Bypass is also expected to benefit adult sDPS green sturgeon access to habitat (National Marine Fisheries Service 2018g).

RPA Action I.6.1: Restoration of Floodplain Rearing Habitat (Increase Juvenile Salmonid Access to Yolo Bypass, and Increase Duration and Frequency of Yolo Bypass Floodplain Inundation)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation, and DWR shall increase juvenile salmonid access to the Yolo Bypass and improve adult fish passage by constructing an operable gated structure in the Fremont Weir. The facility shall be operated to increase the duration and frequency of Yolo bypass inundation from December through April, providing 17,000+ acres of enhanced floodplain habitat. This is expected to benefit salmonids because lack of floodplain connectivity limits food availability and production and leads to reduced fish growth and subsequent survival. Reclamation expects to construct the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project in 2020, to partially fulfill the requirements in RPA Action I.6.1. This action is expected to result in benefits to juvenile listed salmonids through increased growth and survival. Improving access to the Yolo Bypass is also expected to benefit green sturgeon juveniles (National Marine Fisheries Service 2018g).

RPA Action Suite V, NF 4: Implementation of Pilot Reintroduction Program (Implementation of Pilot Reintroduction Program above Shasta Dam)

Pursuant to the RPA in NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation, and DWR shall complete all required actions, monitoring, and reporting to guide establishment of an additional population of winter-run Chinook salmon and identify the benefits and risks of reintroduction for CV spring-run Chinook salmon and CCV steelhead in the McCloud River and/or upper Sacramento River. This action is also a Priority 1 NMFS recovery. Additional updated information related to implementation is available in the Salmon Resiliency Strategy (California National Resources Agency 2017).

In 2010, pursuant to the requirements of RPA Action V in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation established the Interagency Fish Passage Steering Committee, with representatives from Reclamation, NMFS, USFWS, United States Forest Service (USFS), CDFW, DWR, SWRCB, and U.C. Davis. The Steering Committee focused preliminary evaluation efforts on fish passage above Shasta Dam, Folsom Dam and the upper Stanislaus River. By 2013, focus on the fish passage program was limited to the upper Sacramento and McCloud rivers due in large part to the scope of the RPA and concerns over the endangered status of SR winter-run Chinook salmon.

Reclamation prepared a final Environmental Impact Statement (EIS) with a targeted release for the summer of 2018, in anticipation of implementation of the first phase of the pilot reintroduction program scheduled for fall, 2018. To date, the EIS has not been released. Additionally, in 2018, Reclamation awarded DWR 2.7 million dollars as the first installment of a 5-year contract totaling approximately 9 million dollars for the design, construction, installation, and operation of two juvenile fish collection devices in the lower McCloud River and the McCloud arm of Shasta Reservoir. In July, 2018, Reclamation informed the Steering Committee

that the project was "on hold" and had been defunded for the foreseeable future. Since July, 2018, DWR has continued to move forward with the juvenile collection facilities, but has not received additional financial contributions from Reclamation. Progress on RPA V implementation, aside from DWR's efforts, has stopped.

RPA Action IV.1.3: Consider Engineering Solutions to Further Reduce Diversion of Emigrating Juvenile Salmonids to the Interior and Southern Delta, and Reduce Exposure to CVP and SWP Export Facilities (Including Georgiana Slough Non-Physical Barrier)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), DWR, Reclamation and the State and Federal Water Contractors shall increase the overall through-Delta survival of salmonids by reducing juvenile salmon entry into the interior Delta. This action is expected to benefit salmonids because it affects multiple habitat attributes that are hypothesized to affect juvenile survival, including predation and competition, outmigration cues, and entrainment risk. Construction of a non-physical barrier at Georgiana Slough is planned for 2020.

This action is consistent with a priority 1 NMFS recovery action for winter-run Chinook salmon.

RPA Action I.2.6: Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead (Complete Battle Creek Salmon and Steelhead Restoration Project)

Pursuant to the RPA in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), Reclamation, and DWR shall provide improved instream flow releases and safe fish passage to prime salmon and steelhead habitat on Battle Creek for winter-run Chinook salmon, CV springrun Chinook salmon, and CCV steelhead. This is also a Priority 1 NMFS recovery action (National Marine Fisheries Service 2014b). The project has been supported with Federal, State, and private funding. As of 2019, implementation of the Battle Creek Salmon and Steelhead Restoration Project has completed construction of phase 1 (of 2), which included removal of one fish passage barrier (dam), and construction of NMFS-approved fish screens and ladders at the two remaining dams on North Fork Battle Creek. Phase 2 of the project has completed planning, and is currently in design phase. Although implementation has been significantly delayed, we expect benefits to listed salmonids once completed. Additionally, beginning in 2018, winter-run Chinook salmon juveniles produced at LSNFH have been released into North Fork Battle Creek in an effort to jump-start the reintroduction efforts described in the plan (ICF International 2016). These releases are expected to continue until implementation of the full reintroduction plan is underway. Additional updated information related to implementation is available in the Salmon Resiliency Strategy (California National Resources Agency 2017).

Other RPA Actions

Specific smaller scale fish habitat restoration actions mandated as part of the NMFS 2009 Opinion (National Marine Fisheries Service 2009b) are occurring on the upper reaches of the Sacramento River between Keswick Dam and RBDD as well as on the lower American River between Nimbus Dam and the State Route 160 Bridge. At select sites within these areas, the projects involve creation of side channels, addition of spawning gravel, and placement of inwater woody material. NMFS has determined that actions that have been implemented have begun to contribute improvements to aquatic habitat, and are expected to continuing to contribute to the recovery of ESA-listed salmonids in the Central Valley.

2.4.2.9 EcoRestore

California EcoRestore is a California Natural Resources Agency initiative implemented in coordination with State and Federal agencies to advance the restoration of at least 30,000 acres of Delta habitat by 2020. Driven by world-class science and guided by adaptive management, California EcoRestore will pursue habitat restoration projects with clearly defined goals, measurable objectives, and financial resources to help ensure success. The types of habitat and projects targeted include tidal wetlands, floodplain, upland, riparian, fish passage improvements and others.

Specific restoration targets include a focus on implementing a comprehensive suite of habitat restoration actions to support the long-term health of the Delta and its native fish and wildlife species. Specifically, the EcoRestore program aims to create 3,500 acres of managed wetlands created, 17,500 acres of floodplain restoration, 30,000 acres of delta habitat restoration and protection, 9,000 acres of tidal and sub-tidal habitat restoration, and 1,000 acres of proposition 1 and 1E funded restoration projects.

There have been six completed actions as part of EcoRestore to date (California National Resources Agency 2017), which has resulted in improved migration and rearing habitats for listed anadromous fish in the lower Sacramento River and Delta. Completed actions include:

- 1. Knights Landing Outfall Gate Located one-quarter mile from the confluence with the Sacramento River near Knights Landing, just below RM 90, in Yolo County. This Fish Passage Restoration project is a positive fish barrier (with new concrete wing walls and installation of a metal picket weir) to serve primarily as a fish passage improvement action, preventing salmon entry into the Colusa Basin Drain while also maintaining outflows and appropriate water surface elevations. The project was initiated because adult salmon may be able to enter the Colusa Basin Drain through the Knights Landing Outfall Gates when certain flow velocities are met that attract migrating salmon. Once salmon enter the Colusa Basin Drain, there is no upstream route for salmon to return to the Sacramento River and, absent fish rescue operations, the fish perish and are lost from production. Completion of the project has resulted in increased survival at this location, due to decreased entrainment.
- 2. Lindsey Slough Completed in 2014. The project consisted of (1) excavation and debris removal to enlarge an existing north embankment breach on Calhoun Cut at a northern arm of Lindsey Slough; (2) breaching of the south embankment of Calhoun Cut; (3) excavation of a 1-mile long channel at the historic southern arm of Lindsey Slough; (4) lowering of an existing earthen causeway on the historic channel; and (5) beneficial reuse of sediment excavated from the channel to create low habitat berms within the marsh and raise the remnant marsh site to a more mature marshplain form. The project was implemented to restore habitat function and connectivity to Delta wetlands and waterways that had been degraded by the construction of dikes and culverts 100 years earlier. Completion of the project has restored habitat function and connectivity to 159 acres of freshwater emergent wetlands and 69 acres of alkali wetlands, and recreated and reconnected a 1-mile tidal channel.
- 3. Sherman Island: Mayberry Farms The Mayberry Farms Subsidence Reversal and Carbon Sequestration Project is a permanently flooded wetland on a 307-acre parcel on

- Sherman Island that is owned by the DWR. Completion of this project occurred in 2010, and has restored approximately 192 acres of emergent wetlands and enhanced approximately 115-acres of seasonally flooded wetlands.
- 4. Sherman Island: Whale's Mouth The Wetland Restoration Project is to restore approximately 600 acres of palustrine emergent wetlands, within an 877-acre Project boundary, on a nearly 975-acre parcel of property on Sherman Island. Additional project goals include increasing stability and reduced seepage on a threatened section of levee; determining the rates/amounts of carbon sequestered for project; determining the air and water quality impacts of project; and providing recommendations for Delta-wide implementation. This project was initiated in 2013 and was completed in 2015.
- 5. Sherman Island: Mayberry Slough Tidal Marsh, Shaded Aquatic Riverine, and Upland Habitats Restoration Targets: 192 acres of emergent wetlands and 115 acres seasonally flooded wetlands. The DWR, in coordination with Reclamation District 341, constructed 6,100 linear feet of habitat setback levee to increase levee stability and provide waterside habitat restoration along Mayberry Slough on Sherman Island. This project was initiated in 2004 and was completed in 2009.
- 6. Wallace Weir Fish Rescue Facility This project was completed in 2016, and includes replacing the seasonal earthen dam at Wallace Weir with a permanent, operable structure that would provide year-round operational control. The project also includes a fish rescue facility that would return special status migratory fish species back to the Sacramento River that are unable to pass volitionally over Wallace Weir. Wallace Weir has been treated as a common element to the larger habitat restoration and fish passage projects included as an RPA in the NMFS 2009 Opinion. This project will serve primarily as a fish passage improvement action that will prevent upstream migration of straying adult salmonids and sturgeon into the Colusa Basin Drain. Operational control of water levels would also provide greater flexibility for managing water releases for agriculture and wetlands habitat. As background for this action, in 2013, the CDFW and NMFS documented several hundred adult salmon in dead end agricultural ditches in the Colusa Basin Drain system, and while many of these fish were rescued from the drain, the stress from the poor water quality conditions prevented these salmon from successfully contributing to the reproductive population. In the remainder of 2013 and in 2014, CDFW operated a fyke trap with wing walls at Wallace Weir to prevent straying adult salmonids and sturgeon from entering the Colusa Basin Drain; rescued fish were returned to the Sacramento River. These fish rescue operations have proven resource intensive and are not efficient at higher flows in the Knights Landing Ridge Cut (KLRC). Wallace Weir is a key water control structure in the bypass for flood conveyance and irrigation, but it is an obsolete structure, which must be installed and removed annually using inflexible, labor-intensive methods.

2.4.2.10 Ongoing Habitat Restoration and Monitoring Actions

There have been a number of habitat restoration actions occurring in the action area, many of which are expected to continue to benefit listed fish. Some of the restoration actions are ongoing and require repeated annual implementation at a specific site or watershed (e.g., gravel augmentation below Keswick Dam). Others include program level commitments with detailed

restoration actions to be determined at a later date (e.g., side channel restoration). One such program is the NOAA Restoration Center's Program to Facilitate Restoration Projects in the Central Valley (National Marine Fisheries Service 2018d), which is expected to continue making improvements to aquatic and/or riparian habitat for listed fish.

The PA includes restoration actions with annual implementation and are described as conservation measures in Table 4-6 of the ROC on LTO BA (U.S. Bureau of Reclamation 2019). Some of these restoration actions have been consulted on previously such that their past and future beneficial effects to increased spawning and rearing habitat for listed salmonids are factored into the environmental baseline. Examples of previously consulted restoration actions include the Lower Clear Creek Habitat Restoration (National Marine Fisheries Service 2014c), Upper Sacramento River Restoration (National Marine Fisheries Service 2015c), and Lower American River Restoration (National Marine Fisheries Service 2015b), that are carried out under the Central Valley Project Improvement Act.

There are a number of ongoing monitoring and research efforts in the action area, which provide important information on listed anadromous fish. These include monitoring environmental conditions during action implementation (e.g., turbidity or temperature), monitoring fish presence, tagging fish for tracking distribution and survival, monitoring levels of impacts to fish and/or habitat, as examples. The effects of these monitoring and research activities are part of the environmental baseline because they previously have undergone ESA section 7 consultation either through individual or programmatic actions, ESA section 4(d), or section 10(a)(1)(A) incidental take permit. Similarly, any past monitoring that was associated with the NMFS 2009 Opinion is also considered part of the environmental baseline.

2.4.2.11 Conservation/Mitigation Banks

There are a number of conservation or mitigation banks with service areas that include the action area for the PA (described below). Conservation banks present a unique factual situation, and this warrants a particular approach as to how they are addressed in an ESA consultation. Specifically, when NMFS is consulting on a proposed action that includes conservation bank credit purchases, it is likely that physical restoration work at the bank site has already occurred and/or that a Section 7 consultation occurred at the time of bank establishment. A traditional interpretation of the "environmental baseline" might suggest that the overall ecological benefits of the conservation bank actions, therefore, belong in the baseline. However, under this interpretation, all proposed actions, whether or not they included proposed credit purchases, would benefit from the environmental 'lift' of the entire conservation bank because it would be factored into the environmental baseline. In addition, where proposed actions did include credit purchases, it would not be possible to attribute their benefits to the proposed action, without double-counting. These consequences undermine the purposes of conservation banks and also do not reflect the unique circumstances under which they are established. Specifically, conservation banks are established based on the expectation of future credit purchases. In addition, credit purchases as part of a proposed action will also be the subject of a future Section 7 consultation. It is therefore appropriate to treat the beneficial effects of the bank as accruing incrementally at the time of specific credit purchases, not at the time of bank establishment or at the time of bank restoration work. Thus, for all projects within the service area of a conservation bank, only the benefits attributable to credits sold are relevant to the environmental baseline. Where a proposed

action includes credit purchases, the benefits attributable to those credit purchases are considered in the effects of the action.

Liberty Island Native Fisheries Conservation Bank: Established in 2010, the Liberty Island Conservation Bank (Bank) is a conservation bank that serves the Delta region. It is located in the southern Yolo Bypass in Yolo County, California. The Bank consists of 186 acres located on the still leveed northernmost tip of Liberty Island. Approved in July 2010 by the NMFS, USFWS, and CDFW, the Bank provides compensatory mitigation for permitted projects affecting special-status Delta fish species within the region. The Bank provides habitat for all Delta fish species including: Sacramento River winter-run Chinook salmon; CV spring-run Chinook salmon, CCV steelhead, delta smelt, and Central Valley fall- and late fall-run Chinook salmon. Of the 186 total acres, 139.11 acres can be used for salmonid conservation credits. Of the 139.11 acres available for salmonids, approximately 68 acres have been purchased. The habitat includes tidally-influenced shallow freshwater habitat, shaded riparian aquatic (SRA) habitat and Tule Marsh SRA habitat. The increased ecological value of the enhanced rearing habitat for juvenile salmonids (and potentially sDPS green sturgeon), which have already been purchased, are part of the environmental baseline for the Project. Features of the bank are designated as critical habitat for CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

Fremont Landing Conservation Bank: Established in 2006, the Fremont Landing Conservation Bank is 100-acre floodplain site along the Sacramento River (Sacramento RM 80) and is approved by NMFS to provide credits for impacts to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead. There are off-channel shaded aquatic habitat credits, riverine shaded aquatic habitat credits and floodplain credits available. To date, there have been less than 25 percent of the 100 credits sold and the ecological value (increased rearing habitat for juvenile salmonids) of the sold credits are part of the environmental baseline. Features of this bank are designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

Bullock Bend Mitigation Bank: Established in 2016, the Bullock Bend Mitigation Bank is a 119.65-acre floodplain site along the Sacramento River at the confluence of the Feather River (Sacramento RM 106) and is approved by NMFS to provide credits for impacts to Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon and CCV steelhead. There are salmonid floodplain restoration, salmonid floodplain enhancement, and salmonid riparian forest credits available. To date, there have been approximately 10 percent of the 119.65 credits sold and the ecological value (increased rearing habitat for juvenile salmonids) of the sold credits are part of the environmental baseline. Features of this bank are designated critical habitat for the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

2.4.3 Sacramento River Winter-run Chinook Salmon

2.4.3.1 Status of Sacramento River Winter-run Chinook Salmon in the Action Area

The action area encompasses almost all freshwater and estuarine habitats utilized by winter-run Chinook salmon. As such, the Status of the Species for winter-run Chinook salmon (see Section 2.2) describes the species' status within the action area. Here, the biological status of winter-run Chinook salmon in the action area is summarized.

Assessing the temporal occurrence of each life stage is done through monitoring data in the Sacramento River and Delta as well as salvage data from the Tracy and Skinner fish collection facilities in the south Delta (CVP and SWP). Table 2.4.3-1 shows the temporal occurrence of adult and juvenile CCV steelhead at locations in the action area. Darker shades indicate months of greatest relative abundance.

Table 2.4.3-1. The Temporal Occurrence of Adult (a) and Juvenile (b) Winter-run in the Sacramento River and Delta.

Relative Abundance		High			Medium				Low				
a) Adults freshwater													
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Sacramento River													
Upper Sacramento River spanning													
Delta ^d													
b) Juvenile emigration	1						77						
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Sacramento River at Red Bluff ^c													
Sacramento River at Knights Landing ^f													
Sacramento trawl at Sherwood Harbor			Sn										
Midwater trawl at Chipps Island													

Sources: ^a Yoshiyama et al. (1998); Moyle (2002); ^bMyers et al. (1998); ^c Williams (2006); ^d Hallock and Fisher (1985), Vogel and Marine (1991); ^eMartin et al. (2001); ^f Knights Landing Rotary Screw Trap Data, CDFW (1999-2019); ^{g,h} Delta Juvenile Fish Monitoring Program, USFWS (1995-2019), del Rosario et al. (2013).

Sacramento River winter-run Chinook salmon are particularly important among California's salmon runs because they exhibit a life- history strategy found nowhere else in the world. These Chinook salmon are unique because they spawn during the summer months when air temperatures usually approach their warmest. As a result, winter-run Chinook salmon require stream reaches with cold-water sources to protect their incubating eggs from the warm ambient conditions.

Because of this need for cold water during the summer, winter-run Chinook salmon historically spawned only in rivers and creeks fed by cold water springs, such as the Little Sacramento, McCloud, and Pit rivers, and Battle Creek (Lindley et al. 2004). The construction of Shasta and Keswick dams eliminated access to the Little Sacramento, McCloud, and Pit rivers, extirpating the winter-run Chinook salmon populations that spawned and reared there. The fish from these three different populations above Shasta Dam were forced to mix and spawn as one population downstream of Keswick Dam on the Sacramento River. Construction and operation of hydropower facilities in Battle Creek made the creek inhospitable to winter-run Chinook salmon, which resulted in extirpation of the population from that area.

Currently, only the one small population of winter-run Chinook salmon spawning downstream of Keswick Dam exists, making this species particularly vulnerable to environmental pressures such the 2012-2015 drought. This vulnerability manifested during the drought with nearly two consecutive year class failures due to an inability to provide cold water throughout the egg and fry life stages. Warm water releases from Shasta Reservoir in 2014 and 2015 contributed to 5.9 percent and 4.2 percent egg-to-fry survival rates respectively, to RBDD. Under varying hydrologic conditions from 2002 to 2013, winter-run Chinook salmon egg-to-fry survival ranged from three to nearly 10 times higher than in 2014 and 2015. Survival improved after the drought ended with 24 percent survival in 2016, 44 percent survival in 2017, and 26 percent survival in 2018.

Estimates of hatchery-origin winter-run Chinook salmon survival to age 2 are low relative to relevant benchmarks. For winter-run Chinook salmon, the mean smolt-to-adult ratio (SAR) from 1999 to 2012 was 0.64 percent (SE 0.18), well below the Columbia River Basin Fish and Wildlife Program suggested minimum of 2 percent SAR required for population survival and 4 percent for population recovery for Upper Columbia River and Snake River Chinook salmon populations (Michel 2018). SAR should be treated as an index of survival that primarily represents survival from hatchery release to age 2.

Lindley et al. (2007) developed extinction risk criteria for Central Valley salmonid populations based on viability parameters for abundance, population decline rate, and hatchery influence, and using data through 2004, found that the mainstem Sacramento River population was at low risk of extinction, but that the ESU as a whole remained at a high risk of extinction because there is only one naturally-spawning population, and it is not within its historical range. The overall extinction risk of winter-run Chinook salmon has increased since the 2007 and 2010 assessments (Table 2.4.3-2). Based on the Lindley et al. (2007) criteria, the population is at high extinction risk in 2019. High extinction risk for the population was triggered by the hatchery influence criterion, with a mean of 66 percent hatchery origin spawners from 2016 through 2018. The threshold for high risk associated with hatchery influence is 50 percent hatchery origin spawners.

The recent increase in hatchery influence was expected as production from LSNFH was increased during the drought to buffer against low adult returns resulting from poor survival of the 2014- and 2015-year class. This buffering appears to have been successful in the sense that adult escapement through 2018 met the low extinction risk criterion for abundance (i.e., census population size of 2,500).

Table 2.4.3-2. Winter-run Chinook salmon extinction risk based on the criteria established in Lindley et al. (2007).

	20071	2010^2	2015 ³	2019		
Sacramento River	Low	Low	Moderate	High		

¹ Lindley et al. (2007), ²Williams et al. (2011)

2.4.3.2 Status of Sacramento River Winter-run Chinook Critical Habitat in the Action Area

The proposed action area encompasses the entire range wide riverine and estuarine critical habitat PBFs for winter-run. Widespread degradation to these PBFs has had a major contribution

³Williams et al. (2016), ³Williams et al. (2016)

to the status of the winter-run Chinook salmon ESU, which is at high risk of extinction (National Marine Fisheries Service 2016c). PBFs (as discussed in the Section 2.2 Range wide Status of the Species) include: (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River, (2) the availability of clean gravel for spawning substrate (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, (4) water temperatures between 42.5 and 57.5°F (5.8 and 14.1°C) for successful spawning, egg incubation, and fry development, (5) habitat and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean.

Passage impediments in the northern region of the Central Valley are largely responsible for isolating the existing population from historical spawning reaches, which occurred upstream of Keswick and Shasta dams and included the upper Sacramento River, McCloud River, Pit River, Fall River and Hat Creek (Yoshiyama et al. 1996, Lindley et al. 2004), (National Marine Fisheries Service 2014b). Due to the installation of Keswick and Shasta dams, the winter-run ESU is now relegated to spawning downstream, in the Sacramento River. The majority of spawning occurs between RBDD and Redding (below Keswick Dam) (Vogel and Marine 1991, National Marine Fisheries Service 2014b). PBFs #2-4 for this ESU have been degraded in a number of ways. Spatially, the total area of usable spawning habitat has been significantly diminished. Physical features that are essential to the functionality of existing spawning habitat have also been degraded such as: loss of spawning gravel, and elevated water temperatures during summer months when spawning events occur (National Marine Fisheries Service 2014b). Degradation of these features has been actively mitigated through real-time temperature and flow management at Shasta and Keswick dams (National Marine Fisheries Service 2009b) as well as gravel augmentation projects in the affected area, which have been occurring as described in a multi-year programmatic biological opinion (National Marine Fisheries Service 2016b).

PBFs related to the rearing and migration of juveniles and adults have been degraded from their historical condition within the action area as well. Adult passage impediments on the Sacramento River existed for many years at the RBDD and ACID diversion dam (National Marine Fisheries Service 2014b). However, the RBDD was decommissioned in 2013, providing unimpaired juvenile and adult fish passage and a fish passage improvement project at the ACID was completed in 2015, so that adult winter-run Chinook salmon could migrate through the structure at a broader range of flows in order to reach spawning habitat upstream of that structure.

Juvenile migration corridors are impacted by reverse flows in the Delta that become exacerbated by water export operations at the CVP/SWP pumping plants. This results in impaired routing and timing for outmigrating juveniles and is evidenced by the presence of juvenile winter-run Chinook salmon at the State and Federal fish salvage facilities. Shoreline armoring and development has reduced the quality and quantity of floodplain habitat for rearing juveniles in the Delta and Sacramento River (Williams et al. 2009, Boughton and Pike 2013). Juveniles have access to floodplain habitat in the Yolo Bypass only during mid to high water years, and the quantity of floodplain available for rearing during drought years is currently limited. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile salmon over a longer period (California Department of Water Resources and U.S. Bureau of Reclamation 2012).

2.4.4 Central Valley Spring-run Chinook Salmon and California Central Valley Steelhead

2.4.4.1 Status of Central Valley Spring-run Chinook Salmon in the Action Area

Various life stages of CV spring-run Chinook salmon are found in the Sacramento River, Clear Creek, American River, San Joaquin River, Stanislaus River, and the Delta, though the American River only currently supports non-natal rearing of juveniles. Assessing the temporal occurrence of each life stage of spring-run Chinook salmon is done through analysis of monitoring data in the Sacramento River and select tributaries; monitoring in the Delta; and salvage data from the Tracy Fish Collection Facility (TFCF) and Skinner Delta Fish Protection Facility (SDFPF) in the south Delta (CVP and SWP, respectively). Darker shades indicate months of greatest relative abundance.

Table 2.4.4-1 The Temporal Occurrence of Adult (a) and Juvenile (b) Central Valley Spring-run Chinook Salmon in the Mainstem Sacramento River.

Relative Abundance	High				Medium				Low			
(a) Adult Migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Delta ^a												
San Joaquin Basin												
Sac. River Basin ^{b,c}												
Sac. River Mainstem ^{c,d}												
b) Adult Holdingb,c												
c) Adult Spawning ^{b,c,d}												
(b) Juvenile Migration		or c										
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River at RBDD ^d									20 2			
Sac. River at KLi												
San Joaquin basin												
Delta ^j												

Sources: aCDFG (1998); bYoshiyama et al. (1998); Moyle (2002); Myers et al. (1998); Lindley et al. (2004); California Department of Fish and Game (1998); McReynolds et al. (2007); Myers et al. (2003); Snider and Titus (2000b); U.S. Fish and Wildlife Service (2019)

Note: Yearling spring-run Chinook salmon rear in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year spring-run Chinook salmon emigrate during the first spring after they hatch.

Adult spring-run Chinook salmon enter the San Francisco estuary to begin their upstream spawning migration in late January and early February (California Department of Fish and Game 1998). They enter the Sacramento River from March to September, primarily in May and June (Yoshiyama et al. 1998, Moyle 2002). Generally, adult spring-run Chinook salmon are sexually immature when they enter freshwater habitat and must hold in deep pools for up to several

months in preparation for spawning (Moyle 2002). The Delta and Sacramento River provide a critical migration corridor for spawning adults, allowing them access to spawning grounds upstream.

Monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates that some spawning occurs in the river. Although habitat conditions can support spring-run Chinook salmon spawning and incubation in the mainstem, significant hybridization/introgression with fall-run Chinook salmon due to lack of spatial/temporal separation, makes identification of spring-run Chinook salmon in the mainstem very difficult (California Department of Fish and Game 1998). However, counts of Chinook salmon redds in September are typically used as an indicator of the Sacramento River spring-run Chinook salmon population abundance. Less than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts. Redd surveys conducted in September from 2001 to 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the RBDD, ranging from 3 to 105 redds; from 2012 to 2015, redds observed were close to zero except in 2013, when 57 redds were observed in September (California Department of Fish and Wildlife 2017c). Currently, Clear Creek is the only tributary within the action area that has a population of spring-run Chinook salmon.

The Sacramento River mainly functions as both rearing habitat for juveniles and the primary migratory corridor for outmigrating juveniles and spawning adults for all the Sacramento River basin populations. The juvenile life stage of CV spring-run Chinook salmon exhibits varied rearing behavior and outmigration timing. Juveniles may reside in the action area for 12–16 months (these individuals are characterized as "yearlings"), while some may migrate to the ocean as young-of-the-year (National Marine Fisheries Service 2014b).

The Delta is utilized by juveniles prior to entering the ocean. Juvenile spring-run Chinook salmon use Suisun Marsh extensively as a migratory pathway, though they likely move through quickly based on their size upon entering the bay (as compared to fall-run, which enter this area at a smaller size and likely exhibit rearing behavior prior to continuing their outward migration) (Brandes and McLain 2001) (Williams 2012).

Some non-natal juvenile rearing has been observed in the Lower American River (Snider and Titus 2000a). However, there is no longer a spawning population of CV spring-run Chinook associated with that system.

An experimental population of spring-run Chinook salmon has been designated under section 10(j) of the ESA in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River (Snider and Titus 2000a, 78 FR 79622 2013), and spring-run Chinook salmon are currently being reintroduced to the San Joaquin River. The experimental population area in the San Joaquin River is outside the action area. However, when these fish migrate to and from the ocean, they will pass through the action area, where they are considered part of the non-experimental CV spring-run Chinook salmon ESU. A conservation stock of spring-run Chinook is being developed at the San Joaquin River Interim Conservation and Research Facility at Friant Dam and juveniles have been released annually since 2014 to the lower San Joaquin River (CDFW 2014). In 2019, the San Joaquin River Restoration Program released 168,495 San Joaquin River Conservation and Research Facility spring-run Chinook salmon juveniles to the San Joaquin River in Reach 5 of the Restoration Area (Ferguson 2019). As of May 2019, more than 10 adult fish have been detected returning to the San Joaquin River. In the spring of 2018,

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juveniles released in Reach 1 of the Restoration Area were detected at the TFCF, demonstrating volitional passage of juvenile spring-run through the San Joaquin River for the first time in 60 years (National Marine Fisheries Service 2019c).

In addition, observations in the last decade suggest that spring-running populations may currently occur in the Stanislaus and Tuolumne rivers (Franks 2014), tributary rivers to the mainstem San Joaquin River. Although the exact number of spring-running Chinook salmon in the San Joaquin basin is unknown, juvenile and adult spring-run Chinook salmon use the portion of the lower San Joaquin River within the Delta as a migratory pathway.

Spring-run Chinook salmon adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson et al. 2011). Currently, CV spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and without cold water refugia (usually those in higher elevation, input from springs, or snowmelt), those tributaries will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in their natal stream over the summer prior to emigrating (McReynolds et al. 2007), and would be susceptible to warming water temperatures.

Overall, the SWFSC concluded in their viability report that the status of CV spring-run Chinook salmon (until 2014) has probably improved since the 2010/2011 status review and that the ESU's extinction risk may have decreased during that timeframe (Williams et al. 2016). However, the CV spring-run Chinook salmon ESU remains at moderate risk of extinction based on the severity of the drought and the low escapements, as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015. There is concern that these CV spring-run Chinook salmon strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (National Marine Fisheries Service 2016a). This predicted trend has been validated in recent years through escapement data collected by CDFW for Mill and Deer creeks (California Department of Fish and Wildlife 2019), with adult returns below 500 individuals for the fourth consecutive year (2015-2018)(Figure 2.4.4-1).

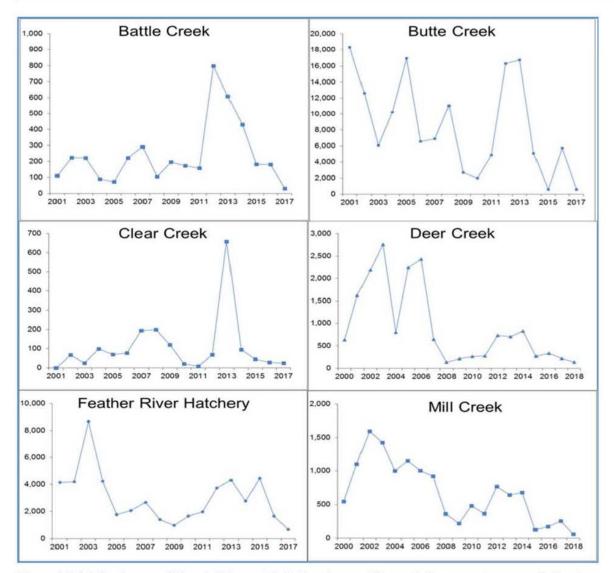


Figure 2.4.4-1 Spring-run Chinook Salmon Adult Abundance. All populations are at or near all-time low levels for adult abundance. Data points from 2018 are preliminary estimates from the California Department of Fish and Wildlife and are subject to change.

The status of spring-run critical habitat in the action area is discussed in Section 2.4.2.2.2 below.

2.4.4.2 Status of California Central Valley Steelhead in the Action Area

Assessing the temporal occurrence of each life stage of CCV steelhead in the action area is done through analysis of monitoring data in the Sacramento River and select tributaries; monitoring in the Delta; and salvage data from the TFCF and SDFPF in the south Delta (CVP and SWP). Table 2.4.4-2 shows the temporal occurrence of adult and juvenile CCV steelhead at locations in the action area.

Table 2.4.4-2 The Temporal Occurrence of (a) Adult and (b) Juvenile California Central Valley Steelhead at Locations in the Action Area. Darker shades indicate months of greatest relative abundance.

Relative Abundance	High					Medium				Low		
(a) Adult migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Delta			8,00		100							
¹ Sacramento R. at Fremont Weir												
² Sacramento R. at RBDD												
³ San Joaquin River												
(b) Juvenile migration	ı											
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
^{1,2} Sacramento R. near Fremont Weir												
⁴ Sacramento R. at Knights Landing												
⁵ Chipps Island (clipped)												
⁵ Chipps Island (unclipped)												
⁶ San Joaquin R. at Mossdale												

Sources: ¹ (Hallock et al. 1957)); ²(McEwan 2001); ³(California Department of Fish and Game 2007); ⁴NMFS analysis of 1998-2018 CDFW data; ⁵NMFS analysis of 1998-2018 USFWS data; ⁵NMFS analysis of 2003-2018 USFWS data.

Spawning adults enter the San Francisco Bay estuary and Delta from August to November (with a peak in September (Hallock et al. 1961). Spawning occurs in a number of tributaries to the Sacramento River, to which the Delta and Sacramento River serve as key migratory corridors. Spawning occurs from December to April, with a peak in January through March, in rivers and streams where cold, well oxygenated water is available (Hallock et al. 1961), (McEwan and Jackson 1996), (Williams 2006). Adults typically spend a few months in freshwater before spawning (Williams 2006) but very little is known about where they hold between entering freshwater and spawning in rivers and streams. Utilization of the Delta by adults is also poorly understood.

Juvenile CCV steelhead rear in cool, clear, fast-flowing streams and are known to prefer riffle habitat over slower-moving pools. Little is known about the rearing behavior of juveniles in the Delta. However, they are thought to exhibit short periods of rearing and foraging in tidal and non-tidal marshes and other shallow areas prior to their final entry into the ocean.

The Lower American River contains a naturally spawning population of CCV steelhead, which spawn downstream of Nimbus Dam. The dam is an impassable barrier to anadromous fish, isolating historical spawning habitat located in the North, Middle and South forks of the upper American River. The American River population is small, with only a few hundred individuals

returning to spawn each year (U.S. Bureau of Reclamation 2015). Spawning adults have been observed with intact adipose fins indicating that a portion of the in-river spawning population is of wild origin (Hannon 2013). Juvenile *O. mykiss* (anadromous and resident forms) have been observed to occupy fast-flowing riffle habitat in the Lower American River, which is consistent with known life history traits of this species.

Nimbus Fish Hatchery, located on the Lower American River adjacent to Nimbus Dam, produces the anadromous form of *O. mykiss*. However, steelhead from Nimbus Fish Hatchery are not included in the CCV steelhead DPS due to genetic integrity concerns from use of out-of-basin broodstock (71 FR 834 2006). To specifically address this issue and in response to RPA Action II.6.1 contained in the NMFS 2009 Opinion (National Marine Fisheries Service 2009b), genetic testing of American River *O. mykiss* population was completed in 2014 to inform the planning for Nimbus Fish Hatchery broodstock replacement that will support the CCV steelhead DPS (National Marine Fisheries Service 2016b).

The portion of the lower San Joaquin River within the Delta is used by migrating adult and juvenile CCV steelhead to reach spawning and rearing grounds in the tributaries (FISHBIO 2012, California Department of Fish and Wildlife 2013b).

Although steelhead will experience similar effects of climate change to Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile steelhead may rear in freshwater over the summer prior to emigrating as smolts (Snider and Titus 2000b). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough et al. 2001). McCullough et al. (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F), and successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F) (Richter and Kolmes 2005). In some areas, stream temperatures that currently provide marginal habitat for spawning and rearing may become too warm to support naturally spawning steelhead populations in the future.

Information on the status of CCV steelhead consist of three types of data sources: direct adult counts, redd counts, and smolt counts. Adult data are the best source, but are complicated by inconsistent counting methods and reporting formats among the hatcheries and weirs. Redd counts represent valuable information from rivers where there are no dams or weirs to block adult migration, but the actual number of adults represented by each redd are unknown. Sampling of smolts in trawls and at the salvage facilities gives us an idea of relative productivity for a region and between hatchery and wild sources, but the survival of these smolts is unknown, and the counts cannot give us estimates of adult abundance. Implementation of CDFW's Central Valley Steelhead Monitoring Program should result in greater consistency in reporting of adult escapement and estimates of abundance that are currently lacking (National Marine Fisheries Service 2016b).

Hatchery production and returns are dominant over natural-origin fish. Continued decline in the ratio between naturally-produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years (National Marine Fisheries Service 2016b).

One continuing strength of the CCV steelhead DPS is the widespread distribution of this species throughout the rivers of the Central Valley. While most of the measured populations are small, steelhead can be found in most of the major rivers and streams of the Sacramento River, San Joaquin River, and eastside tributaries including the Mokelumne River and Calaveras River. Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance, and fluctuating return rates (National Marine Fisheries Service 2016b).

Many watersheds in the Central Valley are experiencing decreased abundance of CCV steelhead. Dam removal and habitat restoration efforts in Clear Creek appear to be benefiting CCV steelhead as recent increases in non-clipped (wild) abundance have been observed. Despite the positive trend in Clear Creek, all other concerns raised in the previous status review remain, including low adult abundances, loss and degradation of a large percentage of the historic spawning and rearing habitat, and domination of smolt production by hatchery fish. Many other planned restoration and reintroduction efforts have yet to be implemented or completed, or are focused on Chinook salmon, and have yet to yield demonstrable improvements in habitat, let alone documented increases in naturally produced steelhead. There are indications that natural production of steelhead continues to decline and is now at a very low levels. Their continued low numbers in most hatcheries, domination by hatchery fish, and relatively sparse monitoring makes the continued existence of naturally reproduced steelhead a concern (National Marine Fisheries Service 2016b).

2.4.4.3 Status of Central Valley Spring-run Chinook Salmon and California Central Valley Steelhead Critical Habitat in the Action Area

A significant portion of designated critical habitat for both CV spring-run Chinook salmon and CCV steelhead is contained within the proposed project action area. PBFs for both species are concurrently defined in (70 FR 52488 2005) and the following PBFs, in summary, for these species are present in the proposed action area: (1) freshwater spawning sites, (2) freshwater rearing sites, (3) freshwater migration corridors, and (4) estuarine areas.

Critical habitat for CV spring-run Chinook includes portions of the north Delta, as well as the Sacramento River and the lower American River (from the confluence with the Sacramento River to the Watt Avenue Bridge). With the exception of Clifton Court Forebay, the entirety of the proposed action area in the Central Valley is designated critical habitat for CCV steelhead.

Historically, both CV spring-run Chinook salmon and CCV steelhead spawned in many of the headwaters and upstream portions of the Sacramento River and San Joaquin River basins. Similar to winter-run Chinook salmon, passage impediments have contributed to substantial reductions in the populations of these species by isolating them from much of their historical spawning habitat. Naturally-spawning spring-run Chinook salmon had been extirpated from the San Joaquin River basin entirely. However, an experimental population has been reintroduced to the river under section 10(j) of the ESA and "spring-running" adults have been documented migrating into the San Joaquin tributaries (Franks 2014). Within the action area, spawning habitat for CV spring-run is currently limited to the mainstem of the Sacramento River between Red Bluff and Keswick Dam, and Clear Creek. CCV steelhead spawn in this reach of the upper accessible Sacramento River, and Clear Creek, as well as throughout the lower American River between its confluence with the Sacramento River up to Nimbus Dam. The PBFs of freshwater

spawning sites has been degraded within the action area due to high water temperatures, redd dewatering, and loss of spawning gravel recruitment in reaches below Keswick Dam (Wright and Schoellhamer 2004, Good et al. 2005, National Marine Fisheries Service 2009b, Jarrett and Killam 2014). These issues are actively addressed by adaptive flow management in both rivers as well as spawning gravel augmentation projects in both reaches.

Freshwater rearing and migration PBFs have been degraded from their historical condition within the action area. In the Sacramento and San Joaquin rivers, bank armoring has significantly reduced the quantity of floodplain rearing habitat for juvenile salmonids and has altered the natural geomorphology of the river (National Marine Fisheries Service 2014b). Similar to winter-run Chinook salmon, CV spring-run and CCV steelhead are only able to access large floodplain areas, such as the Yolo Bypass, under certain hydrologic conditions which do not occur in drier years. However, the Yolo Bypass Restoration Salmonid Habitat Restoration and Fish Passage Implementation Plan includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile spring-run Chinook salmon and steelhead over a longer period (California Department of Water Resources and U.S. Bureau of Reclamation 2016). Levee construction involves the removal of riparian vegetation, resulting in reduced habitat complexity and shading, making juveniles more susceptible to predation. Additionally, loss of riparian vegetation reduces aquatic macroinvertebrate recruitment resulting in decreased food availability for rearing juveniles (Anderson and Sedell 1979, Pusey and Arthington 2003).

The lower American River has experienced similar losses of rearing habitat. However, projects sponsored by Reclamation are restoring rearing habitat for juvenile CCV steelhead through the creation of side channels and placement of instream woody material (U.S. Bureau of Reclamation 2015).

Within the action area of the PA, the estuarine PBFs include the legal Delta, encompassing significant reaches of the Sacramento and San Joaquin rivers that are tidally influenced (70 FR 52488 2005). Estuarine habitat in the Delta is significantly degraded from its historical condition due to levee construction, shoreline development, and dramatic alterations to the natural hydrology of the system due to water export operations (National Marine Fisheries Service 2014b). Though critical habitat for CV spring-run occurs in the north Delta and not the interior or south Delta, entrainment into the interior Delta may occur during DCC gate openings if coinciding with migration. However, the 2014 drought year prompted protections for CV spring-run at the DCC (National Marine Fisheries Service 2016a). Reverse flows in the central and south Delta resulting from water exports may exacerbate interior Delta entrainment by confounding flow and temperature-related migratory cues in outmigrating juveniles. The presence of these stressors, which cause altered migration timing and routing, degrade critical habitat PBFs related to rearing and migration.

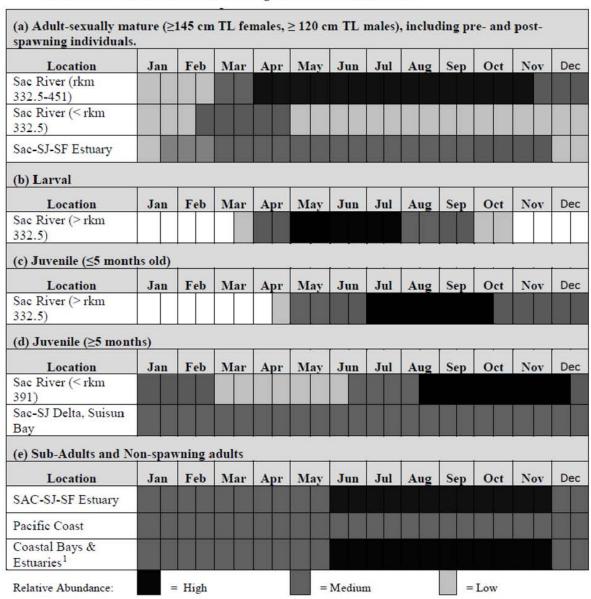
2.4.5 sDPS North American Green Sturgeon

2.4.5.1 Status of sDPS North American Green Sturgeon in the Action Area

The sDPS green sturgeon exhibit a more complex life history with respect to salmonids and less is known about the ecology and behavior of their various life cycle stages in the action area. Some acoustic telemetry (Kelly et al. 2007, Heublein et al. 2009, Thomas et al. 2014, Wyman et al. 2017, Steel et al. 2018, Chapman et al. 2019) and multi-frequency acoustic survey work

(Mora et al. 2015) has been done to study adult migration patterns and habitat use in the action area (Delta and Sacramento River). Field surveys have also been conducted on the Sacramento River to study spatial and temporal occurrence of early life stages (Poytress et al. 2010, Poytress et al. 2011, 2012, 2013) (Table 2.4.5-1). These studies have documented some spatial patterns in spawning events on the upper reaches of the Sacramento River. Spawning occurs in cool sections of the upper Sacramento, Feather, and Yuba rivers in deep pools (>5 meters) with small to medium sized sand, gravel, cobble, or boulder substrate (National Marine Fisheries Service 2018g). Although Seesholtz et al. (2014) and (Beccio 2018) observed spawning in the Feather River and Yuba River, respectively, no known spawning events have been observed in the lower American River or in the portion of the lower San Joaquin River that is included in the Delta. Recently, an eDNA and video-confirmed green sturgeon was observed in the Stanislaus River occupying a pool downstream of Knights Ferry, CA (RK 86.1) (Anderson et al. 2018). Additionally, several lab studies have been conducted using early life stages to investigate ontogenic responses to elevated thermal regimes as well as foraging behavior as a function of substrate type (Allen et al. 2006, Nguyen and Crocker 2006, Linares-Casenave et al. 2013, Poletto et al. 2018). However, due to sparse monitoring data for juvenile, sub-adult and adult life stages in the Sacramento River and Delta, there are significant data gaps to describe the ecology of this species in the action area. Spawning occurs in the upper reaches of the Sacramento River and Feather River (Seesholtz et al. 2014, Poytress et al. 2015). Mainstem Sacramento and Delta serve as rearing habitat and a migratory corridor for this species. Some rearing also may occur in the lowest reaches of the lower American River where deep pools occur for rearing of older life stages (downstream of SR-160 bridge) (Thomas et al. 2013). However, CDFW is currently performing a juvenile monitoring study in the Delta using acoustic telemetry (Beccio 2018). Juvenile green sturgeon rear from 1 to 5 years in the Delta and San Francisco Estuary before entering the ocean as sub-adults. Around age 15, mature adults migrate into the San Francisco Estuary in late winter through early spring to spawn in the Sacramento River and its tributaries primarily from April to July, and generally, adults spawn every 3 to 4 years. Elevated Delta outflow is a likely spawning cue for mature adults to enter the river system. Following spawning, adults may remain in the Sacramento River Basin for up to a year; elevated water flows in the late fall and winter signal outmigration in adults that over-summer in spawning habitats (National Marine Fisheries Service 2018g). Information gaps encountered in efforts to summarize information on sDPS green sturgeon life history are often addressed using known information about the nDPS.

Table 2.4.5-1 The Temporal Occurrence of (a) Spawning Adult, (b) Larval, (c) Young Juvenile, (d) Juvenile, and (e) Sub-adult and Non-spawning Adult Southern DPS Green Sturgeon at Locations in the Action Area. Darker shades indicate months of greatest relative abundance.



Sources: (a) (Heublein et al. 2009, Klimley et al. 2015a, Mora et al. 2015, Poytress et al. 2015, DuBois and Danos 2018, Mora et al. 2018) (b) (Poytress et al. 2015, Heublein et al. 2017); (c) (Poytress et al. 2015, Heublein et al. 2017); (d) (Radtke 1966, California Department of Fish and Game 2002, Poytress et al. 2015, Heublein et al. 2017); (e) (Erickson and Webb 2007, Moser and Lindley 2007, Lindley et al. 2008, Huff et al. 2011, Lindley et al. 2011, DuBois and Danos 2018). Outside of Sac-SJ-SF estuary (e.g. Columbia R., Grays Harbor, Willapa Bay).

Southern DPS green sturgeon spawn primarily in the Sacramento River from April to July, with the farthest upstream spawning event in the Sacramento River documented near Ink's Creek at river km 426 (Poytress et al. 2015). However, Heublein (2009) detected adults as far upstream as river km 451 near Cow Creek, suggesting that their spawning range may extend farther upstream

than previously documented. The upstream extent of their spawning range lies somewhere below ACID (RM 299, or RK 480) as that dam impedes passage for green sturgeon in the Sacramento River (Heublein et al. 2009). However, it is uncertain if green sturgeon spawning habitat exists closer to ACID, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of green sturgeon in other accessible habitats in the Central Valley (i.e., the Feather and Yuba rivers) is limited, in part, by late spring and summer water temperatures and water flow. Similar to salmonids in the Central Valley, green sturgeon spawning in the major lower river tributaries to the Sacramento River are likely to be further limited if water temperatures increase over time. In a bioenergetics study, 15-19°C was the optimal thermal range for age-0 green sturgeon (Mayfield and Cech 2004). If temperatures in spawning habitat exceed that range in the future, it may reduce the fitness of early life stages.

2.4.5.2 Status of sDPS North American Green Sturgeon Critical Habitat in the Action Area

Critical habitat for sDPS green sturgeon is contained in nearly all of the PA's action area for listed anadromous fish with the exception of Clear Creek, the lower American River from the SR-160 bridge upstream to Nimbus Dam, and the Stanislaus River. All PBFs for sDPS green sturgeon critical habitat are present in the action area, except PBFs for nearshore coastal marine areas. The PBFs in the action area include, in summary: (1) food resources; (2) substrate type or size; (3) water flow; (4) water quality; (5) migratory corridor; (6) depth; and (7) sediment quality. These PBFs apply to both riverine and estuarine areas except "substrate type or size," which pertains to spawning habitats and only applies to riverine areas. These PBFs are described in detail in the range wide status of sDPS green sturgeon in Appendix B.

The historical spawning range of sDPS green sturgeon is not well known, though they are thought to have spawned in many of the major tributaries of the Sacramento River basin, many of which are isolated due to passage impediments (Beamesderfer et al. 2004). Green sturgeon utilize the lower Sacramento River for spawning and are known to spawn in its upper reaches between RBDD and Keswick Dam (Poytress et al. 2015). Similar to the listed salmonid species addressed in this Opinion, PBFs related to spawning and egg incubation have been degraded as discussed in Sections 2.2.8. Changes in flow regimes and the installation of Keswick and Shasta dams have significantly reduced the recruitment of spawning gravel in the upper reaches of the lower Sacramento River. Flow conditions in the Sacramento River have also been significantly altered from their historical condition. The degree to which these altered flow regimes affects outmigration dynamics of juveniles is unknown. However, some suitable habitat exists and spawning events have been consistently observed annually (Poytress et al. 2015).

PBFs for sDPS green sturgeon in the lower reaches of the Sacramento River and the Delta have also been significantly altered from their historical condition, similar to the impacts described in Sections 2.4.1.2 and 2.4.2.3. However, green sturgeon exhibit very different life history characteristics from those of salmonids and therefore utilize habitat within the proposed action area differently as follows. Green sturgeon are thought to exhibit rearing behavior in the lower reaches of the Sacramento River and the Delta as juveniles and subadults prior to migrating to the ocean, though little is known about the behavior of these life stages in the Delta (Radtke 1966, National Marine Fisheries Service 2015a). Loss of riparian habitat complexity in the Sacramento River and Delta has likely posed less of a threat to green sturgeon because these life stages are benthically oriented. However, it is likely that reverse flows generated by Delta water

exports affect the green sturgeon juvenile and subadult life stages to some degree as evidenced by juvenile captures at CVP/SWP salvage facilities during high water years (California Department of Fish and Wildlife 2018a).

2.4.6 Importance of the Action Area for the Survival and Recovery of Listed Fish Species

The action area defined for this PA includes critical habitat designated for all species of ESA-listed fish addressed in this Opinion. It includes spawning habitat that is critical for the natural production of these species; rearing habitat that is essential for growth and survival during early life stages and enhances overall productivity and population health; migratory corridors that facilitate anadromous life history strategies; and estuarine habitat that serves as additional rearing habitat and provides a gateway to marine phases of their lifecycle.

The NMFS Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b) provides region-specific recovery actions that were identified by NMFS in order to facilitate recovery of these species. Implementation of some of these actions has already begun and more are in the planning phase.

Recovery criteria for the winter-run Chinook salmon ESU identified in the Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b), includes three viable populations. The Recovery Plan further identified which populations/watersheds have the likely potential to become viable. These include the current population downstream of Keswick Dam on the Sacramento River, reintroducing a population to Battle Creek (tributary to the Sacramento River), and reintroducing a population to the Little Sacramento River or McCloud River upstream of Shasta Dam. As mentioned above, the only current population is being managed by CVP operations. However, implementation of a "jump start" to the reintroduction plan to Battle Creek began in 2018. Reintroduction to McCloud River was part of the 2009 RPA, but has not been implemented past initial studies to date (further description is provided above in Section 2.4.2.9 Restoration Actions from 2009 NMFS RPA).

Recovery criteria for the spring-run Chinook salmon ESU identified in the Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b), includes a total of nine viable populations, spread among four distinct geographical regions (or diversity groups). The Recovery Plan further identified which populations/watersheds have the likely potential to become viable. These include Clear Creek (in the Northwestern California Diversity Group); Battle Creek, and one population upstream of Shasta Dam (in the Basalt and Porous Lava Diversity Group); Butte, Mill, and Deer creeks, as well as upper Yuba River (in the Northern Sierra Nevada Diversity Group); and in the Southern Sierra Nevada Diversity Group - the San Joaquin River below Friant Dam, and one additional population above current impassible dams in either the Stanislaus or Tuolumne rivers. Currently, only three populations, all in the Northern Sierra Nevada Diversity Group, are considered to be both genetically independent and sufficiently high in abundance in most years to warrant "viable or close to viable status." However, these three stronghold populations have been heavily affected by the recent years of drought, such that numbers of returning adults have been extremely low. Additionally, recent expansive and destructive timber fires in anadromous watersheds have left behind large amounts of ash, debris, mountainous bare terrain, and mixed stands of dead and scarred trees/vegetation. Resulting effects of fire can lead to local impacts and alteration of freshwater ecological function (Bisson et al. 2003, Bixby et al. 2015). Years of future impacts are expected associated with

terrain devoid of vegetation, resulting in accelerated erosion/runoff, and physiochemical changes to soil/water chemistry (Johnson et al. 2012).

Recovery criteria for the CCV steelhead DPS identified in the Recovery Plan for Central Valley salmonids (National Marine Fisheries Service 2014b), include a total of nine viable populations, spread among four distinct geographical regions (or diversity groups). The Recovery Plan further identified which populations/watersheds have the likely potential to become viable. Most of the identified steelhead populations are the same as CV spring-run Chinook salmon described above. Some differences include Antelope Creek instead of Butte Creek (for the Northern Sierra Nevada Diversity Group); and Calaveras River instead of the San Joaquin River. Currently, there is still a general lack of data on the status of wild populations. However, the catch of unmarked (wild) steelhead at Chipps Island has been less than 5 percent of the total smolt catch during recent years, which indicates that natural production of steelhead throughout the Central Valley remains at very low levels. Despite the positive trend on Clear Creek and encouraging signs from Mill Creek (both Core 1 Populations), concerns such as low adult abundances, loss and degradation of a large percentage of the historic spawning and rearing habitat, and domination of smolt production by hatchery fish still remain (National Marine Fisheries Service 2016b).

Recovery criteria for sDPS green sturgeon identified in the Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (National Marine Fisheries Service 2018g) include demographic recovery criteria (abundance, distribution, productivity, and diversity) and threat-based recovery criteria (significant known threats impeding recovery). The action area of the PA includes sDPS green sturgeon spawning habitat, adult and juvenile migratory corridors, juvenile rearing habitat, and adult post-spawning holding areas.

2.4.7 Southern Resident Killer Whale

2.4.7.1 Status of Southern Resident Killer Whale in the Action Area

The federally listed SRKW DPS occurs in the action area and may be affected by the proposed action. Please refer to Southern Resident Killer Whale Recovery Plan (National Marine Fisheries Service 2008b) and the most recent 5-year status review (National Marine Fisheries Service 2016e) for more detailed information on the state of knowledge about the status of SRKW and overall threats that are currently facing the species.

In killer whale populations, groups of related matrilines form pods, and three pods (J, K, and L) make up the Southern Resident community. The historical abundance of SRKW is estimated from a low population level of 140 animals to an unknown upper bound. The minimum historical estimate (~140) included whales killed or removed for public display in the 1960s and 1970s, which were added to the remaining population at the time the captures ended (National Marine Fisheries Service 2008b). Several lines of evidence (i.e., known kills and removals (Olesiuk et al. 1990), salmon declines (Krahn et al. 2002), and genetics (Krahn et al. 2002, Ford et al. 2011) all indicate that the population used to be much larger than it is now, but there is currently no reliable estimate of the upper bound of the historical population size. Over the last 5 decades, the SRKW population has remained at a similarly low population size fluctuating from about 80-90 individuals (Olesiuk et al. 1990, Center for Whale Research 2008).

NMFS has continued to fund the Center for Whale Research (CWR) to conduct an annual census of the SRKW population, and census data are now available through December 2018. At the end

of December 2018, the population numbered 74 individuals; K Pod=18, L Pod=34, J Pod=22. The SRKW population has experienced an increase in reproductive females since the beginning of the annual censuses in the 1970s. There is weak evidence of a decline in fecundity rates through time for reproductive females. This decline is linked to fluctuations in abundance of Chinook salmon prey, and possibly other factors (Ward 2014). However, there were six births in 2015, which is higher than observed in recent times. It is unclear yet how these additions to the population will affect the SRKW population dynamics. As of December 2018, the population has decreased to only 74 whales, a historical low in the last 30 years with a current realized growth rate (from 1974 to 2017) at half of the previous estimate described in the science panel report; 0.29 percent.

SRKW spend a substantial amount of time from late spring to early autumn in inland waterways of Washington State and British Columbia, including the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982, Krahn et al. 2002). SRKW occur throughout the coastal waters of Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as southeast Alaska. Although the entire SRKW DPS has the potential to occur in coastal waters at any time during the year, occurrence in coastal waters is more likely from November to May. Satellite-linked tag deployments on K and L pod animals indicate that those pods in particular use the coastal waters along Washington, Oregon, and California during non-summer months (Hanson 2015). Detection rates of K and L pods on passive acoustic recorders indicate the whales occur with greater frequency off the Columbia River delta and Westport, Oregon, and are most common in March (Hanson et al. 2013). Results of recent satellite tagging indicate the limited occurrence along the outer coast by J pod (Hanson 2015) where J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast; members of the J pod do not appear to travel to Oregon or California like K and L pods (Hanson et al. 2013).

As described in the final Recovery Plan for SRKW (National Marine Fisheries Service 2008b), several factors may be limiting recovery of the SRKW DPS. These factors include: quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of SRKW, all identified threats are potential limiting factors in their population dynamics (National Marine Fisheries Service 2008b).

Significant attention has been paid in recent years to the relationship between the Southern Resident population and the abundance of important prey, especially Chinook salmon. Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to SRKW in the summer months using DNA sequencing from whale feces. The researchers found that salmonids made up to over 98 percent of the whales inferred diet, of which almost 80 percent were Chinook salmon. Researchers also found evidence of prey shifting at the end of summer towards coho salmon for all years analyzed; coho salmon contributed to over 40 percent of the diet in late summer. Chum, sockeye, and steelhead made up relatively small contributions to the sequences (less than 3 percent each). Although less is known about the diet of SRKW off the Pacific coast during winter, the available information from observation of predation events indicates that salmon, and Chinook salmon in particular, are also important when the whales occur in coastal waters (Hanson et al. 2010).

One hypothesis as to why killer whales primarily consume Chinook salmon even when they are not the most abundant salmon available is because of the Chinook salmon's relatively high energy content (Ford and Ellis 2006). Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (expressed in kcal/kg) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one average size adult Chinook salmon, it would need to consume approximately 2.7 averaged size coho salmon, 3.1 chum salmon, 3.1 sockeye salmon, or 6.4 pink salmon (O'Neill et al. 2014).

Ford et al. (2005, 2010) evaluated 25 years of demographic data from Southern and Northern Resident killer whales and found that changes in survival largely drive their population, and the populations' survival rates were strongly correlated with coast-wide availability of Chinook salmon. Ward et al. (2009) found that Northern and SRKW fecundity was highly correlated with Chinook salmon abundance indices, and reported the probability of calving increased by 50 percent between low and high Chinook salmon abundance years. More recently, Ward et al. (2013) considered new stock-specific Chinook salmon indices and found strong correlations between the indices of Chinook salmon abundance, such as the West Coast Vancouver Island (WCVI) used by the Pacific Salmon Commission, and killer whale demographic rates. However, no single stock or group of stocks was identified as being most correlated with the whales' demographic rates. Further, they stress that the relative importance of specific stocks to the whales likely changes over time (Ward et al. 2013).

The health of individual SRKW is being studied closely. As a chronic condition, nutritional stress can lead to reduced body size and condition of individuals, and lower reproductive and survival rates of a population (Trites and Donnelly 2003). Very poor body condition is detectable by a depression behind the blowhole that presents as a "peanut-head" appearance. There have been several SRKW that have been observed in recent years with the "peanut-head" condition, and the majority of these individuals died relatively soon after these observations (Durban et al. 2017, Fearnbach et al. 2018). The bodies of the SRKW that died following these observations were not recovered and therefore a definitive cause of death could not be identified. More recently, photographs of whales from an unmanned aerial system (i.e., a drone) have been collected and individual whales in poor condition have been observed. Both females and males across a range of ages were found in poor body condition.

Killer whales are exposed to persistent pollutants primarily through their diet, including Chinook salmon. These harmful pollutants are stored in blubber and can later be released and become redistributed to other tissues when the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons including during gestation or lactation. High levels of these pollutants have been measured in blubber biopsy samples from SRKW (Ross et al. 2000, Krahn et al. 2007, Krahn et al. 2009), and more recently these pollutants were measured in scat samples collected from the whales, providing another potential opportunity to evaluate exposure of SRKW to these pollutants (Lundin et al. 2016). High levels of persistent pollutants have the potential to affect the whales' endocrine and immune systems and reproductive fitness (Krahn et al. 2002), Mongillo et al. in review). As described in National Marine Fisheries Service (2016e), vessel activities may affect foraging efficiency, communication, and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both. Houghton et al. (2015) found that the noise levels killer whales receive are largely determined by the speed of the vessel. Thus, to

reduce noise exposure to the whales, they had recommended reduced vessel speeds. In 2011, NMFS announced final regulations to protect killer whales in Washington State from the effects of various vessel activities (76 FR 20870 2011).

2.4.7.2 Summary of Southern Resident Killer Whale DPS Viability

The viability of the SRKW DPS is evaluated through the consideration of the threats identified in the recovery plan and the population status relative to downlisting criteria. Since completing the recovery plan, NMFS has prioritized actions to address the threats with highest potential for mitigation: salmon recovery, oil spill response, and reducing vessel impacts. Several threats criteria have been met, but many will take years of research and dedicated conservation efforts to satisfy. Salmon recovery is a high priority on the West Coast and there are numerous actions underway to address threats to salmon populations and monitor their status. Recovery of depleted salmon populations is complex and a long-term process. NMFS and partners have successfully developed an oil spill response plan for killer whales (National Marine Fisheries Service 2016e). However, we still have additional work to prepare for a major spill event. NMFS has developed special vessel regulations intended to reduce disturbance of killer whales from vessel traffic. It will take time to evaluate the effectiveness of any new regulations in improving conditions for the whales. Even with progress toward minimizing the impacts of the threats, each of the threats still pose a risk to the survival and recovery of the whales (National Marine Fisheries Service 2016e).

At the time of listing in 2005, there were 88 whales in the population and at the end of 2016, there were 78 whales. Population growth has varied during this time with both increasing and decreasing years. The most recent assessment including data through 2016 now suggests a downward trend in population growth projected over the next 50 years, in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (National Marine Fisheries Service 2016e). The biological downlisting and delisting criteria, including sustained growth over 14 and 28 years, respectively, have not been met (National Marine Fisheries Service 2016e). While some of the biological downlisting and delisting criteria have been met (i.e., representation in all three pods, multiple mature males in each pod), the overall status of the population is not consistent with a healthy, recovered population. Considering the status and continuing threats, the SRKW remain in danger of extinction (National Marine Fisheries Service 2011f).

2.4.7.3 Critical Habitat and Physical or Biological Features for Southern Resident Killer Whale

Designated critical habitat for the SRKW DPS consists of three specific marine areas of Puget Sound, Washington: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca (71 FR 69054 2006). These areas are not part of the action area, and are not expected to be affected by the proposed action; therefore, critical habitat for the SRKW DPS will not be discussed further in this Opinion.

2.4.7.4 Factors Affecting the Prey of Southern Residents in the Action Area

In the Rangewide Status of the Species and Critical Habitat and Environmental Baseline sections for ESA-listed Chinook salmon, we discussed the impacts of various activities and factors

affecting Chinook salmon populations in the freshwater environment and, specifically, the action area in the Central Valley, including major influences such as water operations and climate change. In the past, NMFS has consulted on the effects of the long-term operations of the CVP/SWP in California (National Marine Fisheries Service 2009b). In that analysis, NMFS found that the long-term operations of the CVP and SWP, as proposed, were likely to jeopardize the continued existence of several ESA-listed Chinook salmon ESUs. NMFS concluded that the increased risk of extinction of the winter- and spring-run Chinook salmon, along with loss of diversity in fall-run, as a long-term consequence of the proposed action is likely to reduce the likelihood of survival and recovery of the SRKW DPS, although implementation of the RPA actions for reducing adverse impacts to Chinook salmon was determined sufficient to also reduce adverse impacts on SRKW and avoid jeopardy.

In general, the factors affecting non-listed Chinook salmon (fall-run and late fall-run) in the freshwater environment are identical or very similar to what is discussed for ESA-listed Chinook salmon in the Central Valley. All of these important influences on Chinook salmon in the freshwater environment contribute to the health, productivity, and abundance of Chinook salmon that ultimately survive to reach the ocean environment and influence the prey base and health of SRKW. Given that the factors that affect salmon in the freshwater environment of the Central Valley have already been discussed, this section focuses on important factors for Chinook salmon and for SRKW in the marine environment.

Significance of Prey

As described in the Rangewide Status of Southern Resident Killer Whale section (Section 2.2.9), statistical correlations between various Chinook salmon abundance indices and the vital rates (fecundity and survival) of SRKW have been outlined in several papers. In addition to examining whether any fundamental linkages between vital rates and prey abundance are evident, another primary purpose of many of these analyses has been aimed at distinguishing which Chinook salmon stocks, or grouping of Chinook salmon stocks, may be the most closely related to these vital rates for SRKW. Largely, attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using the strengths of these statistical relationships have not produced clear distinctions as to which are most influential, as most Chinook salmon stock indices are highly correlated with each other. It is also possible that different populations may be more important in different years. Large aggregations of Chinook salmon stocks that reflect abundance on a coastwide scale appear to be as equally or better correlated with Southern Resident vital rates than any specific or smaller aggregations of Chinook salmon stocks, including those that originate from the Fraser River that have been positively identified as key sources of prey for SRKW during certain times of the year in specific areas (see Hilborn et al. 2012, Ward et al. 2013). However, there are still questions about the diet preferences of SRKW throughout the entire year, as well as the relative exposure of SRKW to various Chinook salmon or other salmon stocks outside of inland waters during the summer and fall. To help answer some of these questions, NMFS and Washington Department of Fish and Wildlife (WDFW) recently released a report to help evaluate and identify which Chinook stocks, including Central Valley Chinook salmon, should be priorities for recovery actions to help increase SRKWs' prey base (NMFS and WDFW 2018; described in more detail in Appendix B).

As referenced above, the independent science panel found good evidence that Chinook salmon are a very important part of the SRKW diet and that some SRKW have been in poor condition

recently, which is associated with higher mortality rates. They further found that the data and correlations developed to date provide some support for a cause and effect relationship between salmon abundance and SRKW survival and reproduction. They identified "reasonably strong" evidence that vital rates of SRKW are, to some degree, ultimately affected by broad-scale changes in their primary Chinook salmon prey. They suggested that the effect is likely not linear, however, and that predicted improvements in SRKW survival with increasing abundances of Chinook salmon may not be realistic or may diminish at Chinook salmon abundance levels that are above their historical average (Hilborn et al. 2012). Given all the available information, and considering the uncertainty that has been highlighted, we assume that the overall abundance of Chinook salmon as experienced by foraging SRKW throughout their range may be as influential on their vital rates as any other relationships with any specific Chinook salmon stocks.

Link between Southern Resident Killer Whales and Central Valley Chinook as Prey

As described in the Rangewide Status of Southern Resident Killer Whale section (Section 2.2.9), SRKW (particularly K and L pod) are known to reside in coastal waters along the west coast of U.S. and Canada during the winter and spring, including at least occasional visits to California. The BA describes in general some of what is known about the distribution of Central Valley Chinook salmon in the Pacific Ocean in comparison to the distribution of Southern Residents. Largely, our knowledge of the distribution of these Chinook salmon in the ocean comes from the data obtained from coded wire tags (CWT) and genetic stock information (GSI) obtained from fish harvested in ocean fisheries that generally occur sometime between April and October. Unfortunately, the timing of ocean salmon fisheries does not overlap well with the occurrence of SRKW in coastal waters during the winter and spring, especially in the last few decades. Ocean distribution of Chinook salmon populations based on summer time fishery interactions generally indicates northern movements of Chinook salmon from their spawning origins (Weitkamp 2010), although the range of these movements is quite variable between populations and run timings, and the distribution of Chinook salmon populations in the winter and spring when SRKW are likely to encounter Central Valley Chinook salmon stocks is not as well known. Recently, Shelton et al. (2019) did estimate the seasonal ocean distribution, survivorship, and aggregate abundance of fall-run Chinook salmon stocks from California to British Columbia. While their analysis did not appear to reveal significant seasonal variance in the relative distribution of Chinook salmon stocks from California during the winter and spring compared to the summer and fall, they generally concluded that fall-run Chinook salmon stocks tended to be more northerly distributed in summer than in winter-spring, and ocean distributions also tend to be spatially less concentrated in the winter-spring (Figure 3 in Shelton et al. 2019). Without any additional information available that would suggest the distribution of Central Valley Chinook salmon shifts substantially during the winter or spring, we assume the distribution of Central Valley Chinook salmon during the winter and spring is similar to what has been documented during the summer and fall, and that data collected from hatchery fish (usually where CWTs are applied) are representative of the distribution of both wild and hatchery populations.

The available data from CWT and GSI confirm that Chinook salmon from the Central Valley (particularly fall-run) occur in small numbers as far north as Vancouver Island, British Columbia, but are primarily encountered by ocean salmon fisheries south of the Columbia River (Weitkamp 2010, Bellinger et al. 2015, Shelton et al. 2019). Recent GSI studies by Bellinger et al. (2015) indicated that Central Valley Chinook salmon (primarily fall-run) constituted sizeable

proportions of Chinook salmon sampled off the coast of Oregon and California during the 2010 fishing season where comprehensive GSI data were collected.²

In total, the available data suggest that Central Valley Chinook salmon constitute a sizeable percentage of Chinook salmon that would be expected to be encountered by SRKW in coastal waters off California and Oregon, and at least a small portion of Chinook salmon in the ocean as far north as British Columbia. In addition, ratios of contaminants in blubber biopsies found that the blubber of K and L pod match with similar ratios of contaminants in Chinook salmon from California, which was indicated by the relatively high concentrations of dichlorodiphenyltrichloroethane (DDT). These DDT fingerprints suggest fish from California³ form a significant component of their diets (Krahn et al. 2007, Krahn et al. 2009, O'Neill et al. 2012). As a result, we conclude that Central Valley Chinook salmon are an important part of the diet for most SRKW during portions of the year when SRKW occur in coastal waters off the North American coast, especially south of the Columbia River, which includes the times of potential reduced body condition and increased diet diversity that received additional weight during a recent prey prioritization process described above.

Relationship of Central Valley Chinook to the Total Abundance of Chinook within the Ocean Range of SRKW

Given that the best information available links SRKW population dynamics to the abundance of Chinook salmon available to SRKW at a coast-wide level, and that impacts from the proposed action are expected to occur only to salmon from the California Central Valley, it is important to understand how significant Central Valley Chinook salmon are to the abundance of Chinook salmon within the range of SRKW. Currently, there is no capability to generate specific estimates of the number of Chinook salmon that may be found in the ocean within any defined boundary that would include likely or possible coastal migrations of SRKW during the winter and spring. There are many different management and monitoring schemes that are employed for Chinook salmon along the western North American coast that make it difficult to directly relate and compare metrics of Chinook salmon abundance. A commonly used approach involves use of relative indexes as opposed to absolute measures of abundance, such as the WCVI index that has been previously related to Southern Resident population dynamics (Ward et al. 2013). In addition, many of the estimates or forecasts of Chinook salmon abundance used for management are related to escapements that are not inclusive of adult Chinook salmon that remain in the ocean to mature, or succumb to predation or other forms of mortality. In combination, use of catch and escapement data from Chinook salmon populations that occur in the range of SRKW could provide some minimum measure of the absolute abundance of Chinook salmon that are available, although all of these Chinook salmon individuals would not necessarily always overlap with SRKW during any specific time period given the uncertain and variable migratory nature of Chinook salmon and Southern Residents. Without any comprehensive and consistent monitoring and assessment methodology across Chinook salmon populations throughout the

³ The research does not specify if or how much fish from the Central Valley specifically contribute to the diet; only that SRKW must feed in areas where Chinook with California origins occur. Consistent with the information reviewed, Central Valley Chinook salmon overlap in space and time with Chinook from other California origins like the Klamath River (Shelton et al. 2018).

² Bellinger et al. 2015 estimated that Central Valley Chinook salmon made up about 22% of the Chinook salmon sampled off the Oregon coast and about 50% of those sampled off the California coast (south to Big Sur) during that one-year study. 2010 was a very low year for Central Valley harvest and escapement (PFMC 2019).

range of SRKW, we will combine the data and information that are available for use in generally characterizing the abundance of coast-wide Chinook salmon potentially available to SRKW, as well as the relative importance of Central Valley Chinook salmon to that total.

In general, ocean abundance estimates for Chinook salmon that originate from U.S. systems are provided by the Pacific Fisheries Management Council (PFMC 2019). The estimated 2019 ocean abundance of Sacramento River fall-run Chinook salmon (Sacramento Index, or SI), which constitutes most of the Chinook salmon that are harvested in the ocean or return to the Central Valley in terms of abundance, is 379,600 fish (PFMC 2019)⁴. Winter, spring, and late fall-run Chinook salmon are not included in the SI index. These runs combined collectively constitute approximately 10 percent of all Central Valley Chinook salmon returns on average; ranging from 5-27 percent of Central Valley Chinook salmon returns over the last two decades (California Department of Fish and Wildlife 2019). Since the early 1980s, SI values commonly range from 500,000 to 1 million fish, although recent abundances have been much smaller than historical averages, and SI values have exceeded 300,000 only 3 times in the last 12 years (PFMC 2019). In 2019, the Klamath River was estimated to have an ocean abundance of 274,00 fish; which is generally consistent with the average ocean abundance of Klamath over the last 10 years (PFMC 2019). Including escapement forecasts for Columbia River Chinook salmon stocks (514,400 fish) with other stocks south of the Strait of Juan de Fuca (48,800 fish); along with Puget Sound, Hood Canal, and the Strait of Juan de Fuca combined (243,800 fish); the total Chinook salmon abundance from these sources equals 1,460,800 fish in 2019 (PFMC 2019), of which 379,600/1,460,800=26 percent originate from the Central Valley. As mentioned, 2019 is expected to be a relatively low abundance year compared to historical perspectives for Sacramento River fall-run Chinook salmon based on the SI forecast, which historically would be more significant to the overall abundance especially in the action area.

While the estimated proportion of Chinook salmon originating from the Central Valley for 2019 does include accounting of most of the significant populations of Chinook salmon along the U.S. coast, this does not include any totals from significant Canadian Chinook salmon populations that are likely encountered by SRKW to some degree, in particular Fraser River and West Coast Vancouver Island stocks. Although abundance estimates or escapement forecasts for 2019 are not readily available for these Chinook salmon stocks (largely managed through relative abundance indices), it is possible to look at historical catch and escapement numbers to get a sense of at least the minimum number of these fish that are in the ocean in the range of SRKW at some point each year. During the independent science panel, historical estimates of catch and escapement for most all major Chinook salmon stocks from British Columbia to California were produced (Kope and Parken 2011). Across all major Chinook salmon populations, Kope and Parken (2011) reported that the total number of Chinook salmon that were either captured or escaped annually from 1979-2010 ranged from about 2-6 million; commonly between 3 and 4 million fish. Although these totals are certainly an underestimate of all the Chinook salmon that could be present in coastal waters along the west coast associated with these populations, and the

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⁴ The Sacramento Index (SI) is limited to a measure of catch and escapement abundance, and not absolute abundance in the ocean. The SI index is the sum of (1) adult Sacramento River Fall Chinook (SRFC) salmon ocean fishery harvest south of Cape Falcon, OR (2) adult SRFC impacts from non-retention ocean fisheries when they occur, (3) the recreational harvest of adult SRFC in the Sacramento River Basin, and (4) the SRFC adult spawner escapement. The SI forecasting approach uses jack escapement estimates to predict the SI (PFMC 2019).

precise overlap of SRKW with all these populations at all times during the year is not well established, we conclude based on the historical catch and escapement data presented above that the relative magnitude of Chinook salmon in the range of SRKW each year is likely at least several million fish. Based on the tabulations of catch and escapement conducted by Kope and Parken (2011), we can get a sense of the relative contribution of Central Valley Chinook salmon (as represented by the SI) to the total abundance of Chinook salmon in the range of SRKW. On average since the early 1980s, it appears that the SI constitutes about 20 percent of the total catch and escapement of all these Chinook salmon populations that are likely encountered by SRKW to some degree, although this proportion varies from about 10-30 percent each year depending on varying strengths in run size (Kope and Parken 2011). As a result, we conclude that Central Valley Chinook salmon make up a sizeable and significant portion of the total abundance of Chinook salmon available to SRKW throughout their range in most if not all years; likely at least several hundred thousand individual fish other than during years of exceptionally low abundance for Central Valley Chinook salmon. In addition, the known distributions of Chinook salmon along the coast suggest that Central Valley Chinook salmon are an increasingly significant prey source (as SRKW move south along the U.S. West Coast) during any southerly movements of SRKW along the coast of Oregon and California that may occur during the winter and spring (Weitkamp 2010, Bellinger et al. 2015, Shelton et al. 2019).

Climate Change and Environmental Factors in the Ocean

The availability of Chinook salmon to SRKW is affected by a number of environmental factors and climate change. Predation in the ocean contributes to natural mortality of salmon in addition to predation in freshwater and estuarine habitats, and salmonids are prey for pelagic fishes, birds, and a wide variety of marine mammals (including SRKW). Recent work by Chasco et al. (2017) estimated that marine mammal predation of Chinook salmon off the West Coast of North America has more than doubled over the last 40 years. They found that resident salmon-eating killer whales consume the most Chinook salmon by biomass, but harbor seals consume the most individual Chinook salmon (typically smolts). In particular, they noted that southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, and that SRKW may be the most disadvantaged compared to other more northern resident killer whale populations given the northern migrations of Chinook salmon stocks in the ocean. Ultimately, Chasco et al. (2017) concluded that these increases in marine mammal predation of Chinook salmon could be masking recovery efforts for salmon stocks, and that competition with other marine mammals may be limiting the growth of the SRKW population.

Recent studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions related to Pacific Decadal Oscillation and the El Nino-Southern Oscillation conditions and events, as well as the recent northeast Pacific marine warming phenomenon (aka "the blob") (Peterson et al. 2006, Wells et al. 2008). Evidence exists that suggests early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and a local scale, provides an indication of the role they play in salmon survival in the ocean. Moreover, when discussing the potential extinctions of salmon populations, Francis and Mantua (2003) point out that climate patterns would not likely be the sole cause, but could certainly increase the risk of extinction when combined with other factors, especially in ecosystems under stress from humans.

Salmon Harvest Actions

NMFS has consulted on the effects of numerous salmon fishery harvest actions that may affect Chinook salmon availability in coastal waters for SRKW, including the Pacific Coast Salmon Plan fisheries (National Marine Fisheries Service 2009a), the 10-year term of the Pacific Salmon Treaty [term of biological opinion from 2009-2018; (National Marine Fisheries Service 2008a), and 2019-2028; (National Marine Fisheries Service 2019b) and the United States v. Oregon 2018 Management Agreement (term of biological opinion from 2018-2027; National Marine Fisheries Service 2018f)]. In these past harvest Opinions, NMFS has considered the short-term effects to SRKW resulting from reductions in Chinook salmon abundance that occur during a specified time period and the long-term effects to whales that could result if harvest affected viability of the salmon stock over time by decreasing the number of fish that escape to spawn. These past analyses suggested that short-term prey reductions were small relative to remaining prev available to the whales. In the long term, harvest actions have been designed or modified via RPAs to meet the conservation objectives of harvested stocks in a manner determined not likely to appreciably reduce the survival and recovery of listed Chinook salmon, and therefore ultimately not likely to jeopardize the continued existence of listed Chinook salmon. The harvest Opinions referenced above that considered potential effects to SRKW have all concluded that the harvest actions cause prey reductions, but were not likely to jeopardize the continued existence of ESA-listed Chinook salmon or SRKW.

Ocean harvest rates of Chinook salmon throughout the range of SRKW are highly variable on a stock-by-stock basis as influenced by factors that include variable management goals or limits for different stocks and/or geographic areas, along with variable overlap in fishing effort and the abundance and distribution of stocks and fishing effort. Overall, Hilborn et al. (2012) generally assumed that all salmon fisheries reduced Chinook salmon abundance for SRKW by approximately 20 percent each year under current harvest management regimes. Although precise estimates of exploitation rates for all Central Valley Chinook salmon populations are not readily available, the estimated harvest of Sacramento River fall-run Chinook salmon typically is equal to or exceeds the estimated escapement of fall-run Chinook salmon in the Sacramento River as represented SI used for fisheries management each year (Pacific Fishery Management Council 2019).

As part of the recent the Pacific Salmon Treaty negotiation, the U.S. agreed to develop a targeted funding initiative to mitigate the effects of harvest and other limiting factors by investing in habitat and hatchery actions to increase prey available for SRKW (NMFS 2019a). Those actions are anticipated to increase Chinook salmon abundance and prey for SRKW by four to five percent throughout their range in Puget Sound waters during the summer, and in coastal areas during the winter when prey is believed to be most limiting. It is expected that an additional 20 million Chinook salmon smolts will be produced by facilities in Puget Sound and along the Washington coast and Columbia River. To a large degree, Chinook salmon from these origins will only overlap with the small percentage of Chinook salmon from the Central Valley that range up to the Columbia River area and northward.

Water Operations

Recently, NMFS completed consultation on the operation of the Klamath River water project from 2019-2024, which included measures to address disease concerns for juvenile Chinook and coho salmon in the Klamath Basin (National Marine Fisheries Service 2019a). The analysis of

the proposed action indicated that the juvenile survival rates to ocean entry for Chinook salmon would improve overall; by as much as 18 percent during years (typically drier) when disease may be a significant threat. As a result, we expect hundreds or thousands of more adult Chinook salmon from the Klamath River will be available for SRKW off the coast of California and Oregon during some years over the next decade, especially for brood years that may have been exposed to more stressful conditions.

Scientific Research

Research activities on SRKW are typically conducted between May and October in inland waters, and some permits include authorization to conduct research in coastal waters as well. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Recent permits issued by NMFS include research to characterize the population size, structure, feeding, ecology, behavior, movement patterns and habitat use of the SRKW, especially during the winter and spring when SRKW are using coastal waters extensively. Impacts from permitted research include temporary disturbance and potential short-term disruptions or changes in behavior such as feeding or social interactions with researchers in close proximity, and any minor injuries that may be associated with biopsy samplings or attachment of tags for tracking movements and behavior. We note that in 2016, a SRKW (L95) was found to have died of a fungal infection that may have been related to a satellite tag deployment approximately 5 weeks prior to its death (Carretta et al. 2018).

Other Factors Affecting SRKW in the Action Area

As described above in the Section 2.2.9. Rangewide Status of the Species, SRKW are affected by a number of activities and stresses in marine environment, including vessel activity, anthropogenic sounds resulting from various sources, and potential exposure to oil spills. All of these potential impacts are occurring or remain constant stresses or threats to SRKW throughout their range, including when they occur in coastal waters within the action area.

Summary of Environmental Baseline

SRKW are exposed to a wide variety of human activities and environmental factors in the action area. All the activities discussed above in Section 2.2.9 Rangewide Status of the Species are likely to have some level of impact on SRKW when they are in the action area. No single threat has been directly linked to or identified as the cause of the relative lack of growth of the SRKW population over time, although three primary threats that have been identified are: prey availability, environmental contaminants, and vessel effects and sound (Krahn et al. 2002). There is limited information on how these factors or additional unknown factors may be affecting SRKW when in coastal waters. However, the small size of the population increases the level of concern about all of these risks (National Marine Fisheries Service 2008b).

2.5 Effects of the Action on the Species

In Table 4-6 of the BA (U.S. Bureau of Reclamation 2019), Reclamation identified a number of restoration actions or programs that have been occurring, and which are expected to continue into future. An analysis of any negative and/or beneficial effects to fish and their habitat has been completed for those actions or programs that previously underwent separate ESA section 7 consultations, and are therefore described in the environmental baseline section. For those programs or actions Reclamation identified as linked to the PA, and will continue into the future,

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we consider any expected continued negative and/or beneficial effects to listed fish and habitat at a broader scale – or "framework-level" only. For any identified new restoration programs or actions that lack sufficient detail to analyze and quantify level of impact at the level of incidental take, the program or action would require a separate section 7 consultation when sufficient details are available. Any "conservation measure" type actions in Table 4-6 of the BA, would be handled in the same manner described above.

Reclamation also identified existing monitoring and research programs and actions linked to the PA in Appendix C of the BA (U.S. Bureau of Reclamation 2019). Effects of any existing research and monitoring programs and actions that have been previously analyzed through an ESA Section 7, 4(d), or 10 process are considered to be in the environmental baseline. For those research or monitoring programs proposed to continue into the future, we consider any expected continued negative and/or beneficial effects to listed fish and habitat at a "framework-level" only. For any identified new research or monitoring programs or actions that lack sufficient detail to analyze and quantify level of impact at the level of incidental take, the program or action would require a separate ESA compliance when sufficient details are available.

All modeling used to inform the following effects analysis reflects the incorporation of a 2030 scenario of climate conditions, water demands, and build-out, as discussed in Section 2.1 Analytical Approach. Therefore, the evaluation implicitly includes a climate change condition (Section 2.5.10 Climate Change). However, considering the 4th California Climate Assessment, NMFS expects that in-river temperatures will be even greater than what was presented in the BA modeling. NMFS cannot quantify the effect of this on species, but will assume that the provided modeling represents a scenario of lower effect and will layer additional qualitative evaluations of increased climate effects to the species based on the updated assessments. Regarding sea level rise, NMFS considers the modeling of the PA as the scenario of lower effect and consistent with the 4th CA Assessment for 2030; however, it is considered as an absolute lower effect for late 2000s when the assessment projects much greater increases than those captured in the modeling of 2030 in the BA.

Detailed descriptions of the modeling used to inform the effects analysis are available as appendices to this Opinion. Specifically, Appendix H--WRLCM is the model description for the Sacramento River Winter-run Chinook Salmon Life Cycle Model (WRLCM). Appendix D provides descriptions of the Delta Passage Model (DPM), the Interactive Object-Oriented Simulation (IOS) and the SALMOD Model. These were extracted from Appendix 5.D of(U.S. Bureau of Reclamation 2016a) because the same methods, without modification, were applied in Reclamation's analysis of that project and the documentation is still accurate. Likewise, Appendix G, describing the Salvage Density Model, was also extracted from the CWF biological assessment Appendix 5.D. Appendix E contains a description of the Reclamation Salmon Mortality Model (SacSalMort) which was included in Attachment 5.D.1 of the ROC on LTO biological assessment. Lastly, Appendix F describes the methods used for the Science Integration Team's (SIT) Model Floodplain Habitat Analyses for the rivers and bypasses considered in the analysis of the ROC on LTO.

The effects of the PA is organized by Division and species. Table 2.5-1 provides an overview of the species for which the effects are analyzed in each Division.

Table 2.5-1: Overview of the species for which the effects are analyzed in each Division. An "X" indicates the species will be analyzed for that Division and a "-" indicates that effects are not analyzed because the species is not present in the Division. A "*" indicates that while no effects analysis is done for that species in that Division, NMFS acknowledges that some life stage of the species may occasionally be there (for example, adult winter-run Chinook salmon in Clear Creek, winter-run juveniles in the American River, or adult green sturgeon in the Stanislaus River).

Division	Upper Sacramento/Shasta Division	Clear Creek/Whiskeytown	American River Division	Bay Delta Division	Stanislaus River (East Side Division)	San Joaquin River ⁵
Sacramento River winter-run Chinook salmon	х	*	*6	X	-	-
Central Valley spring-run Chinook salmon	х	X	-	X	Х	Х
California Central Valley steelhead	Х	x	х	x	х	х
Southern Distinct Population Segment of North American green sturgeon	х	-	-	Х	*7	х
Southern Resident Killer Whale ⁸	; = ;s		:: +	-	-	-

2.5.1 Stressors and Species Response

The following stressors are considered in the analysis of effects of the proposed action: Passage Impediments/Barriers, Harvest and Angling Impacts, Water Temperature, Water Quality, Flow Conditions, Loss of Natural River Morphology and Function, Loss of Floodplain Habitats, Spawning Habitat Availability, Physical Habitat Alteration, Invasive Species/Food Web Disruption, Predation, and Hatchery Effects. These stressors were previously identified during the development of the Central Valley salmonid and green sturgeon recovery plans as being the

⁵ In this Opinion, this area is defined as the reach of the San Joaquin River between the confluence with the Stanislaus River and approximately Mossdale.

⁶ In addition to the Sacramento River, juvenile winter-run Chinook salmon have also been found to rear in areas including the lower American River, lower Feather River, Battle Creek, Mill Creek, Deer Creek, and the Delta (Phillis et al. 2018). Phillis et al (2018) found with isotope data that 44 to 65 percent of surviving winter-run Chinook salmon adults reared in non-natal habitats as juveniles.

⁷ Records of green sturgeon in the San Joaquin River and its tributaries are rare and limited to information from angler report cards. However, Anderson et al. (2018) recently confirmed an adult green sturgeon holding in a deep pool near Knights Ferry in the Stanislaus River in the fall of 2017.

⁸ Effects to Southern Resident killer whale prey analyzed in Section 2.5.8.

primary stressors affecting the recovery of the species. In the analysis of the effects of the action, NMFS uses the description of each stressor as the standard against which to measure the severity or magnitude of impact associated with a particular action component. In this way NMFS measures the effects of the action against the factors known to affect recovery of the species, and where the effect of the PA either increases, decreases, or has an unknown or indiscernible effect on those stressors.

2.5.1.1 Passage Impediments/Barriers

Passage Impediments/Barriers was identified as a primary stressor affecting the recovery of Central Valley salmonid species (National Marine Fisheries Service 2014b) because construction of barriers since the 1800s has caused a 95 percent reduction in river and stream spawning habitat available to Central Valley salmon and steelhead (California Department of Fish and Game 1993). Construction of new impediments can further limit access to spawning habitats in a way that reduces habitat connectivity. Passage impediments and barriers are considered to be threats affecting adult immigration and staging, spawning, embryo incubation, and juvenile rearing and outmigration life stages of Chinook salmon, steelhead, and sturgeon from the Delta to the upper river reaches. Effects of the action that contribute to Passage Impediments/Barriers are likely to result in a probable change in fitness of: reduced reproductive success and reduced lifetime reproductive success.

Natural and artificial barriers can delay the upstream passage and increase energetic costs to migration for salmon. These impediments physically block access to upstream historic holding and spawning habitats, alter downstream habitat (by disrupting water velocity, temperature, and sediment transport) and eliminate the spatial segregation of spawning habitat that historically existed. This can create cascading effects of fragmented habitat, constrained species distributions, isolate genetic pools, increased competition for spawning sites, and favoring generalist over specialist life histories which poses a particular risk to endemic species (Poff et al. 2007, Liermann et al. 2012).

For sturgeon *Passage Impediments/Barriers* to migration caused by impoundments were recognized as a high threat to the sDPS green sturgeon (*Acipenser medirostris*) in the Sacramento River Basin (National Marine Fisheries Service 2018g). Large dams constructed on the Sacramento, Feather, and Yuba rivers have restricted spawning and rearing areas for green sturgeon by presenting a physical barrier to migration. Impassible barriers were recognized as a main threat to the green sturgeon in the original listing decision as well as in subsequent status reviews. These barriers, along with water management actions that divert water for other uses and restrict water at certain times of year, affect river flow volumes and temperatures throughout the year. Flow may be an important cue for migration and can factor into successful spawning, egg deposition, and early life stage development.

Passage Impediments/Barriers also includes temporary or operable barriers such as the Delta Cross Channel Gate, which can negatively impact migration. Operation of the Delta Cross Channel Gate may influence downstream migration by providing false migration cues for juvenile and adult salmon and sturgeon to move from lower Sacramento River to the central Delta rather than their intended destination of the western Delta and San Francisco Bay. Likewise temporary agricultural barriers, constructed in the spring to provide water surface elevation protection for Delta agricultural diverters (U.S. Bureau of Reclamation 2019), can

cause delays to migration or result in the isolation of fish, preventing them from reaching suitable habitats. DWR issued a report regarding the effects of the south Delta agricultural barriers on the survival of emigrating juvenile salmonids, including both Chinook salmon and steelhead (California Department of Water Resources 2018b). This study showed that by delaying migration and increasing the time that juvenile salmonids spent in the vicinity of the barriers, the fish were increasingly exposed to elevated water temperatures as the season progressed. This could in turn diminish the physiological state of the fish making them more vulnerable to predation. Some impediments have been alleviated in recent years through efforts like the fish passage improvement project at RBDD which reduces impacts to both salmonids and sturgeon.

2.5.1.2 Harvest and Angling Impacts

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), the *Harvest and Angling Impacts* stressor was identified as affecting the recovery of the species. Angling Impacts primarily affect the adult immigration and staging life stages from the Ocean, Bay, and Delta, to lower, middle, and upper reaches of the Central Valley rivers; as well as impacts to the spawning and embryo incubation life stages in the upper rivers. Effects of the action that contribute to *Harvest and Angling Impacts* are likely to result in a probable change in fitness of: reduced survival probability, reduced reproductive success and reduced lifetime reproductive success.

Harvest and Angling Impacts refers to the total number or weight of fish caught and kept from an area over a period of time including commercial landings and recreational angling. Harvest and Angling Impacts also includes incidental impacts such as bycatch in mixed stock fisheries or anglers disturbing incubating embryos if they wade through redds. The multi-agency Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) synthesis teams also identified the relevant pathways by which Harvest and Angling Impacts is likely to affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) noted that harvest is one of the three primary factors affect salmon survival during the ocean phase of their lifecycle (along with food supply and predation) and that mortality is highest during the first year of the ocean phase, which strongly influences spawning.

The number of Chinook salmon harvested in the California commercial salmon fishery dramatically declined starting in 2006. From 1978 to 2005, the annual salmon harvest for the California commercial fishery exceeded 300,000 in all but one year (2001). In 2006 the fishery collapsed resulting in complete fishery closures in 2008 and 2009, and a heavily restricted fishery in 2010 (NMFS 2014). Sacramento River adult fall Chinook salmon escapement has now remained below the 180,000 goal 8 of the past 12 years [Figure II-1, (Pacific Fishery Management Council 2019)]. It is now possible for this ocean fishery to be managed for specific river fisheries through genetic sampling of the ocean harvest along the Pacific Coast. This change has altered the way ocean harvest is regulated, and protects critical species in that life stage. Seasonal time/area restrictions and minimum size limits for the sport and commercial ocean salmon fisheries are in place for the protection of winter-run Chinook salmon. Additionally, there is a regulatory management framework to further reduce ocean fishery impacts when the status of winter-run is declining or unfavorable (National Marine Fisheries Service 2012). In rivers, potential impacts of anglers include the capture of adults or incidentally physically disturbing incubating embryos while wading through the river. The State has

established specific in-river fishing regulations and no-retention prohibitions designed to protect winter-run Chinook salmon during their freshwater life stages.

Harvest protective measures benefiting spring-run Chinook salmon include seasonal constraints on sport and commercial fisheries south of Point Arena. In addition, the State has listed spring-run Chinook under the California Endangered Species Act (CESA), and has thus established specific in-river fishing regulations and no-retention prohibitions designed to protect this ESU (e.g., fishing method restrictions, gear restrictions, bait limitations, seasonal closures, and zero bag limits), in tributaries such as Deer, Big Chico, Mill, and Butte creeks. Because there is no commercial fishery for Central Valley steelhead and the recreational fishery is regulated to protect wild steelhead, there is some reason to think that fishing impacts would not be a significant problem for this species. However, because the sizes of Central Valley steelhead populations are largely unknown, it is difficult to make conclusions about the impact of the recreational fishery (Good et al. 2005). The State also works closely with NMFS to review and improve inland fishing regulations. As a result, zero bag limits for unmarked steelhead, gear restrictions, closures, and size limits designed to protect smolts are additional inland harvest measures that protect CCV steelhead.

2.5.1.3 Water Temperature

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), *Water Temperature* was identified as a primary stressor affecting the recovery of the species. This threat affects all life stages: adult immigration, staging, juvenile rearing and outmigration in the Delta and rivers of the Central Valley; and spawning and embryo incubation in the upper reaches. Effects of the action that contribute to the *Water Temperature* are likely to result in a probable change in fitness of: reduced growth, reduced survival probability, reduced reproductive success and reduced lifetime reproductive success.

Water Temperature in this context refers to thermal stress that can affect the physiology of ectothermic organisms like salmon and sturgeon. These effects can impact the organism directly (e.g. altered metabolic demand), as well as indirectly by altering their habitat (e.g. decreased dissolved oxygen or increased water chemistry reaction rates). Water temperatures can be affected by a number of factors, including air temperatures, elevation, flow and velocity, and presence of riparian vegetation. Riparian vegetation, specifically SRA habitat, provides overhead cover, which results in shade and protection, increases large woody material recruitment, provides slower flow velocities for resting spots, and provides substrate for food production (such as aquatic and terrestrial invertebrates) for anadromous fish (Anderson and Sedell 1979, Pusey and Arthington 2003). A vibrant riparian corridor provides important water temperature cooling, especially in smaller streams. The loss of riparian vegetation can therefore increase predation rates and reduce food production and feeding rates for juveniles. This interaction with the Loss of Riparian Habitat and Instream Cover stressor may also expose anadromous fish juveniles to increased water temperatures when the riparian corridor has been degraded, which may result in decreased growth and survival (U.S. Fish and Wildlife Service 1992, Michel 2010). There is also a high threat posed by altered water temperatures due to climate change. In the Sacramento River Basin, climate change models predict increased air temperatures in the Central Valley and surrounding mountains (Ficklin et al. 2012), altered precipitation patterns with a higher frequency of dry years, reduced spring snowpack, and reduced spring flows (Knowles and

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Cayan 2002, CH2M HILL 2014). Water temperatures in the Sacramento River Basin could also increase (CH2M HILL 2014). A warming climate with continued changes in precipitation patterns may influence reservoir operations and thus influence water temperature and flow that fish experience in the Central Valley.

The multi-agency SAIL synthesis teams also identified the relevant pathways by which *Water Temperature* is likely to affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) focused on the effects of water temperature on the rate of development of embryos and alevins (Rombough 1988, Beacham and Murray 1989), temperature thresholds, and interactions with dissolved oxygen saturation concentration which has been positively correlated with Chinook salmon larval growth.

Chinook salmon, CCV steelhead, and sDPS green sturgeon are dependent on a range of optimal water temperatures for survival, which vary depending on life stage. Central Valley dams currently block Chinook salmon, CCV steelhead, and sDPS green sturgeon from their historical habitat, confining them to a limited amount of thermally suitable habitat for adult holding, spawning, and rearing. As a result, flow releases combined with cold-water temperature management downstream of dams is necessary to provide habitat suitable for fresh-water life stages.

Spawning and holding winter-run and CV spring-run Chinook salmon are dependent on cold water releases because they hold and spawn during the summer months. Based on several studies on CV Chinook salmon, temperatures between 43°F and 54°F (6°C and 12°C) appear best suited to Chinook salmon egg and larval development (Myrick and Cech 2004). Several studies indicated that daily temperatures over 56°F (13.3°C) would lead to sub-lethal and lethal effects to incubating eggs (Seymour 1956, Boles 1988a, U.S. Fish and Wildlife Service 1999, U.S. Environmental Protection Agency 2003). A 56°F (13.3°C) temperature compliance target was included in the NMFS 2009 Opinion to protect the sensitive life-stages of listed Chinook salmon in Clear Creek and the Sacramento River (National Marine Fisheries Service 2009b). However, recent investigations into causes of mortality upstream also revealed that the 56°F (13.3°C) daily average temperature may not be adequate to protect the earliest life stages (Swart 2016). The Martin et al. (2016) egg mortality model found strong evidence that significant thermal mortality occurs at temperatures >53.5°F (12°C), supporting the conclusion that the 56°F (13.3°C) daily temperature criteria mandated in the NMFS 2009 Opinion is likely not sufficiently protective. To improve Sacramento River water temperature management for Chinook salmon, a 2016 pilot study was implemented where the temperature criterion was adjusted to the U.S. Environmental Protection Agency (2003) recommendation of 55°F 7DADM metric and applying it to the Bonneyview Bridge temperature control point which was roughly equivalent to a daily average temperature of 53.5°F at Clear Creek (Swart 2016).

Every salmonid life stage is dependent on suitable temperatures. Besides spawning and egg incubation, juvenile rearing also occurs in the upper Sacramento River. Salmonids with a stream life history, such as spring-run Chinook salmon and steelhead, need suitable spawning and rearing temperatures to be maintained year round. The larger salmonid juvenile life stages are less sensitive to temperature than the alevins and yolk-sac fry, but will suffer lethal and sublethal effects when not in optimal instream temperatures. The EPA guidelines recommend water temperatures do not exceed 61°F (16°C) 7-day average daily maximum (7DADM) for juvenile rearing salmonids in the upper basin of natal rivers and do not exceed 64°F (18°C) in the lower

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basin of natal rivers (U.S. Environmental Protection Agency 2003). Potential sub-lethal temperature effects on juvenile salmonids include slowed growth, delayed smoltification, desmoltification, and extreme physiological changes, which can lead to disease and increased predation. Myrick and Cech (2004) reviewed the published information on Central Valley salmon and steelhead temperature tolerance and growth and noted that several studies suggest that the optimal temperature for Chinook salmon growth lies within the 63°F to 68°F (17 to 20°C) range (Brett et al. 1982, Clarke and Shelbourn 1985, Myrick and Cech Jr 2002, Marine and Cech 2004, Myrick and Cech 2004).

Green sturgeon have different temperature requirements than salmonids in the upper Sacramento River. The majority of green sturgeon spawn above Red Bluff Diversion Dam. Suitable spawning temperatures must remain below 63°F (17.5°C) to reduce sub-lethal and lethal effects. Temperatures in the range of 57° to 62°F (14 to 17°C) appear to be optimal for embryonic development (Van Eenennaam et al. 2005). Juvenile sturgeon can tolerate higher temperatures and optimal bioenergetics performance was found to be between 59 to 66°F (15 to 19°C) (Mayfield and Cech 2004). Although optimal temperatures for green sturgeon are typically higher than temperatures suitable for salmon egg incubation green sturgeon energy budget modelling has found that water-temperature management for the eggs of the endangered Sacramento River winter-run Chinook salmon have a relatively small impact on the growth rate of green sturgeon (Hamda et al. 2019).

The threat posed to sDPS green sturgeon by altered water temperatures due to impoundments was ranked high in the Sacramento River Basin for eggs and juveniles. Impoundments alter flow regimes, which in turn affect the water temperature of the river downstream of the impoundment. If water released from the impoundments results in water temperatures that are not within the optimal thermal window for development, survival and growth will be limited.

Sacramento River temperature management was rated as a medium threat to all life stages of sDPS green sturgeon. Under laboratory conditions, Mayfield and Cech (2004) reported optimal bio-energetic performance of age-0 and age-1 Northern DPS green sturgeon at 15 to 19°C. Summer water temperatures in the upper Sacramento River have typically been below this range, within lab-based optima for green sturgeon egg development but below lab-based optima for green sturgeon larval and juvenile growth (Mayfield and Cech 2004, Van Eenennaam et al. 2005, Allen et al. 2006). Notably, temperatures throughout the upper Sacramento River were in excess of 13.3°C during periods of 2014 and 2015 due to historic drought but the effect of this on sDPS green sturgeon production remains unclear. Although the first successful season of directed juvenile green sturgeon sampling near RBDD occurred during elevated temperatures in 2015, juveniles were subsequently collected in 2016 and 2017 sampling efforts [As cited in (National Marine Fisheries Service 2018g)]. Furthermore, high larval sDPS green sturgeon catch at RBDD has occurred in years with relatively low water temperatures (1995, 2011, 2016, and 2017; [As cited in (National Marine Fisheries Service 2018g)]). The effect of cold-water releases from Keswick Dam may have a greater impact on green sturgeon spawning and incubation in the uppermost accessible reach of the Sacramento River below Anderson-Cottonwood Irrigation District (ACID) Dam. The ACID Dam currently serves as a migration barrier, but low water temperature could deter green sturgeon spawning even if passage was restored to this reach.

2.5.1.4 Water Quality

Water Quality is identified as a primary stressor affecting the recovery of the species in the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b). This threat includes dissolved oxygen, heavy metals, and agricultural and urban runoff affecting adult immigration and staging and juvenile rearing and outmigration from the San Francisco Bay through the Delta and the Sacramento River. Especially threatening is the stress of water pollution in the Upper Sacramento River impacting embryo incubation. Effects of the action that contribute to the Water Quality are likely to result in a probable change in fitness of: reduced growth, reduced survival probability, reduced reproductive success, and/or reduced lifetime reproductive success.

Water Quality encompasses the physical, chemical, and biological properties of aquatic environments. Physical properties include temperature, turbidity, and dissolved gases. Chemical properties include pH, hardness, organic and inorganic contaminants, and metals. Biological properties include pathogens, fishes, insects, algae, and other organisms. The Water Quality stressor discussed below focuses on threats from Contaminants and Oxygen is the crucial final electron acceptor in the Krebs Cycle energy-producing pathway, but despite efficient physiological mechanisms for obtaining and using oxygen, it is often a limiting factor for fish who spend considerable energy in perfusion, ventilation, and/or locomotion to extract dissolved oxygen from dense and viscous water (Kramer 1987). In order to avoid suffocation, fish can potentially compensate for hypoxia behaviorally with increases in air or surface breathing or changes in activity or habitat use (Breitburg 2002). Dissolved oxygen impacts on all fish lifestages, including embryos, juveniles, and adults. The embryonic stage is particularly vulnerable due to their immobility, as studies depriving salmon eggs of adequate oxygen observed deformities, premature hatching or delay in emergence, smaller and weaker sac fry, and death (Alderdice et al. 1958, Silver et al. 1963, Geist et al. 2006). Reductions in swimming performance and preference/avoidance behavior can impose costs on fish, for example migrating adult Chinook exhibited an avoidance response when dissolved oxygen was below 4.2 mg/L and most waited to migrate until dissolved oxygen levels were at 5 mg/L or higher (Hallock et al. 1970, Bjornn and Reiser 1991, Carter 2005).

Turbidity.

The multi-agency SAIL synthesis teams also identified the relevant pathways by which *Water Quality* is likely to affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) focused on water quality gradients and poor water quality factors such as low dissolved oxygen, noting that these factors influence fish condition and behavior.

2.5.1.4.1 Contaminants

Many freshwater taxa in the Central Valley are in noticeable decline. This includes ESA-listed species and their designated critical habitat, which are susceptible to contaminants, many of which interact with other stressors such as pathogens to cause mortality, reproductive failure, and other losses to individual fitness. Many ESA-listed fish species in the Central Valley are highly mobile and traverse hundreds of kilometers of freshwater habitat from the Sacramento-San Joaquin River Delta on their migration path to and from the ocean (Quinn 2005).

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Chemical forms of water pollution are a major cause of freshwater habitat degradation worldwide. There are many sources of contaminants, and these reflect past and present human activities and land use (Scholz and McIntyre 2015). Contaminants are typically associated with areas of urban development, agriculture, or other anthropogenic activities (e.g., mercury contamination as a result of gold mining or processing). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (i.e., heavy metals) concentrations may deleteriously affect early life-stage survival of fish in the Central Valley watersheds (National Marine Fisheries Service 2011c, 2013b). Legacy contaminants such as mercury, PCBs, heavy metals, and persistent organochlorine pesticides, however, continue to be found in watersheds throughout the Central Valley. Persistent organic pollutants such as PCBs disrupt immune system function in exposed fish, thereby rendering exposed fish more susceptible to disease. PCBs are considered persistent pollutants because they resist degradation in the environment, by processes that are either biotic (e.g., microbial breakdown) or abiotic (e.g., photolysis in response to sunlight). They accumulate in sediments and can be resuspended and redistributed in aquatic habitat by dredging and similar forms of human disturbance.

Alterations of flow into the San Francisco Bay Delta Estuary can also effect related water quality measures (e.g. salinity, sediment, nutrients, metals, and phytoplankton growth) (Cloern and Jassby 2012). These hydrologic alterations can impact the fate and transport of pollutants (e.g. sequestering or resuspending, diluting or concentrating, and increasing or decreasing bioavailability). The resulting toxicity can kill or impede fish (e.g. degrading movements essential to predator avoidance, reproduction, social behaviors, or migration). The degree to which this is a threat is difficult to quantify and often site-specific. Zones of degraded water quality, such as chemical or thermal plumes or hypoxic zones without adequate zones of passage (Environmental Protection Agency 2014), can impede fish movement (Sprague and Drury 1969, Giattina and Garton 1983, Scott and Sloman 2004).

Adult salmonid exposure within the Delta is limited and not likely to affect reproduction. However, survival and growth of juvenile salmonids will potentially be affected. In contrast, green sturgeon may remain in or return to the Delta at all life stages such that survival, growth, and reproduction are all important characteristics to consider for green sturgeon.

Metals, PCBs, and hydrocarbons (typically oil and grease) are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Many of these contaminants readily adhere to sediment particles and tend to settle out of solution relatively close to the primary source of contaminants. PCBs are persistent, adsorb to soil and organic matter, and accumulate in the food web. Lead and other metals also will adhere to particulates and can bioaccumulate to levels sufficient to cause adverse biological effects. Mercury is also present in the Sacramento River system and could be sequestered in riverbed sediments. Hydrocarbons biodegrade over time in an aqueous environment and do not tend to bioaccumulate or persist in aquatic systems.

If bioaccumulative contaminants such as organochlorines are resuspended from sediments into the water column, they can biomagnify in aquatic food webs. That is, they become proportionately more concentrated at higher trophic levels. Consequently, they present a greater risk to fish that feed at or near the top of aquatic food webs. Exposure to contaminated food sources and bioaccumulation of contaminants from feeding on them may create delayed sublethal effects that negatively affect the growth, reproductive development, and reproductive

success of listed anadromous fishes, thereby reducing their overall fitness and survival (Laetz et al. 2009). The effects of bioaccumulation are of particular concern as pollutants can reach concentrations in higher trophic level organisms (e.g., salmonids) that far exceed ambient environmental levels (Allen and Hardy 1980).

Bioaccumulation may therefore cause delayed stress, injury, or death as contaminants are transported from lower trophic levels (e.g., benthic invertebrates or other prey species) to predators long after the contaminants have entered the environment or food chain. Many contaminants lack defined regulatory exposure criteria that are relevant to listed salmonids and yet may have effects on salmonids (Ewing 1999). It follows that some organisms may be negatively affected by contaminants while regulatory thresholds for the contaminants are not exceeded during measurements of water or sediments.

Rand (1995) stated that the most common sublethal endpoints in aquatic organisms are behavioral (e.g., swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (e.g., growth, reproduction, and development), biochemical (e.g., blood enzyme and ion levels), and histological changes. Some sublethal effects may result in indirect mortality, for example, when a fish already stressed due to toxicity encounters an additional stressor and the combination of those causes death. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of listed fish to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish of the same species may exhibit different responses to the same concentration of toxicant. In addition, the individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants and may succumb to toxicant levels that are considered sublethal to a healthy fish.

Exposure to sublethal levels of contaminants has been shown to have serious implications for salmonid health and survival. Studies have shown that low concentrations of commonly available pesticides can induce significant sublethal effects on salmonids. Scholz et al. (2000) and Moore and Waring (1996) have found that diazinon interferes with a range of physiological biochemical pathways that regulate olfaction, negatively affecting homing, reproductive, and anti-predator behavior of salmonids. Waring and Moore (1997) also found that the carbofuran had significant effects on olfactory mediated behavior and physiology in Atlantic salmon (*Salmo salar*). Scientific literature on the effects of pesticides on salmonids and identified a wide range of sublethal effects such as impaired swimming performance, increased predation of juveniles, altered temperature selection behavior, reduced schooling behavior, impaired migratory abilities, and impaired seawater adaptation (Sandahl et al. 2007, Baldwin et al. 2009, Laetz et al. 2009, McIntyre et al. 2012, Laetz et al. 2013) are reviewed Ewing (1999). Other non-pesticide compounds that are common constituents of urban pollution and agricultural runoff also have the potential to negatively affect salmonids.

Green sturgeon are expected to be more vulnerable than salmonids to sediment contamination due to their benthic-oriented behavior, which conceivably put them in closer proximity to the contaminated sediment horizon, although it is presently unclear if juveniles exhibit this behavior

to the same extent that adults do (Presser and Luoma 2010b, 2013). Their "inactive" resting behavior on substrate may potentially put them in dermal contact with contaminated sites, which can lead to lesions and the production of tumors from materials in the substrate. Sturgeon are also benthic invertebrate feeders that forage on organisms that can sequester contaminants at much higher levels than the ambient water or sediment content, such as the Asian clams *Corbicula* and *Potamocorbula* that are prevalent in the action area, a non-native species known to bioaccumulate selenium (California Department of Fish and Game 2002, Linville et al. 2002). Laboratory research has revealed that green sturgeon are highly sensitive to selenium with potential impacts including reduced growth and organ abnormalities (Bakke et al. 2010, Silvestre et al. 2010, Lee et al. 2011, De Riu et al. 2014).

The great longevity of sturgeons also places them at risk for the bioaccumulation of contaminants to levels that create physiologically adverse conditions within the body of the fish. Contaminants found in the Sacramento River Basin were determined to pose the greatest threat to green sturgeon eggs, larvae, and juveniles, resulting in reduced growth, injury, or mortality. Contaminants could also negatively affect the reproductive capacity of female adults during spawning. In addition, pyrethroid insecticides used in crop protection and home pest control may affect aquatic invertebrates and the prey base of the green sturgeon. A recent Biological Opinion found that the pesticides chlorpyrifos, diazinon, and malathion jeopardize green sturgeon and adversely modify their critical habitat (National Marine Fisheries Service 2017a). These pesticides were found to potentially cause direct mortality, impaired behavior, and a reduced prey base and could impact green sturgeon in the Sacramento River Basin and San Francisco Bay Delta Estuary environments (National Marine Fisheries Service 2017a).

2.5.1.4.2 Dissolved Oxygen

Oxygen is the crucial final electron acceptor in the Krebs Cycle energy-producing pathway, but despite efficient physiological mechanisms for obtaining and using oxygen, it is often a limiting factor for fish who spend considerable energy in perfusion, ventilation, and/or locomotion to extract dissolved oxygen from dense and viscous water (Kramer 1987). In order to avoid suffocation, fish can potentially compensate for hypoxia behaviorally with increases in air or surface breathing or changes in activity or habitat use (Breitburg 2002). Dissolved oxygen impacts on all fish lifestages, including embryos, juveniles, and adults. The embryonic stage is particularly vulnerable due to their immobility, as studies depriving salmon eggs of adequate oxygen observed deformities, premature hatching or delay in emergence, smaller and weaker sac fry, and death (Alderdice et al. 1958, Silver et al. 1963, Geist et al. 2006). Reductions in swimming performance and preference/avoidance behavior can impose costs on fish, for example migrating adult Chinook exhibited an avoidance response when dissolved oxygen was below 4.2 mg/L and most waited to migrate until dissolved oxygen levels were at 5 mg/L or higher (Hallock et al. 1970, Bjornn and Reiser 1991, Carter 2005).

2.5.1.4.3 Turbidity

Elevated turbidity and suspended sediment levels have the potential to adversely affect salmonids during all freshwater life stages. Specifically increased turbidity can clog or abrade gill surfaces, adhering to eggs, hamper fry emergence (Phillips and Campbell 1961), bury eggs or alevins, scour and fill in pools and riffles, reduce primary productivity and photosynthesis

activity (Cordone and Kelley 1961), and affect intergravel permeability and dissolved oxygen levels (Lisle and Eads 1991, Zimmermann and Lapointe 2005).

Fish behavioral and physiological responses indicative of stress include: gill flaring, coughing, avoidance, and increased blood sugar levels (Berg and Northcote 1985, Servizi and Martens 1992). Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995). Changes in turbidity and suspended sediment levels associated with water operations may negatively impact fish populations temporarily when deposition of fine sediments fills interstitial substrate spaces in food-producing riffles, reducing the abundance and availability of aquatic insects and cover for juvenile salmonids (Bjornn and Reiser 1991). Suspended solids and turbidity generally do not acutely affect aquatic organisms unless they reach extremely high levels (i.e., levels of suspended solids reaching 25 mg/L). At these high levels, suspended solids can adversely affect the physiology and behavior of aquatic organisms and may suppress photosynthetic activity at the base of food webs, affecting aquatic organisms either directly or indirectly (Alabaster and Lloyd 1980, Lloyd 1987, Waters 1995).

Increased sediment concentrations can also affect fish by reducing feeding efficiency or success and stimulating behavioral changes. Sigler et al. (1984) found that turbidities between 25 and 50 Nephelometric Turbidity Units (NTU) reduced growth of juvenile coho salmon and steelhead, and Bisson and Bilby (1982) reported that juvenile coho salmon avoid turbidities exceeding 70 NTUs. Turbidity likely affects Chinook salmon in much the same way it affects juvenile steelhead and coho salmon because of similar physiological and life history requirements between the species. Newcombe and Jensen (1996) also found increases in turbidity could lead to reduced feeding rate and behavioral changes such as alarm reactions, displacement or abandonment of cover, and avoidance, which can lead to increased predation and reduced feeding. At high suspended sediment concentrations for prolonged periods, lethal effects can occur.

Conversely, impoundments upstream of bays and estuaries may result in a long-term reduction in turbidity by holding back sediment and this could conceivably increase interactions between green sturgeon and large predators such as marine mammals and sharks. This can impact green sturgeon feeding habitat quality and quantity through changes in sediment deposition and composition and subsequent changes in prey resources or through changes in turbidity that could impact habitat use and predation by sight-predators.

2.5.1.5 Flow Conditions

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), *Flow Conditions* was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the adult immigration and staging (with Lower Sacramento River low flows for attraction and migratory cues, and flood flows for non-natal area attraction, as well as in the Middle & Upper Sacramento River low flows for attraction and migratory cues), Spawning and Embryo Incubation (with upper Sacramento River flow fluctuations), and Juvenile Rearing and Outmigration (with Changes in Delta Hydrology, Diversions into the Central Delta, Reverse Flow Conditions in the Delta, Flow Dependent Habitat Availability in the Lower Sacramento River, Flow Dependent Habitat Availability in the Middle and Upper Sacramento River).

Effects of the action that contribute to the *Flow Conditions* are likely to result in a probable change in fitness of: reduced growth, reduced survival probability, reduced reproductive success and/or reduced lifetime reproductive success. *Flow Conditions* refer here to the quantity, timing, and quality of water flows required to sustain fishes and the ecosystems upon which they depend. Numerous other stressors are superimposed on flow conditions (e.g. water temperature, water quality, loss of natural river morphology and function, and loss of floodplain habitats), so the discussion below focuses on the following specific facets: hydrologic alteration, redd dewatering, isolation and stranding, travel time & outmigration, and delta survival.

The multi-agency SAIL synthesis teams also identified the relevant pathways by which Flow Conditions is likely to affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) focused on the impacts of flow to migration, spawning, and growth. The authors discuss how flows impact: migration (by altering contaminant concentration, reducing water temperatures, thereby affecting dissolved oxygen, food availability, predation, pathogens, and disease), entrainment and stranding risk, and cues to stimulate outmigration. They also discuss how flow can diminish natural channel formation, alter food web processes, slow regeneration of riparian vegetation, reduce bedload movement causing gravels to become embedded, and decrease channel width due to incision, all of which can decrease the availability and variability of spawning and rearing habitat. Additionally, reduced flows can weaken fish during periods of holding prior to spawning by concentrating fish within a smaller habitat area, thereby increasing the potential for lateral transmission of disease and prespawn mortality; while increased flows can move weakened fish downstream out of the temperature-controlled section of river, reducing spawning success, or laterally to the stream margins, making them more vulnerable to predation, harassment, or poaching. Finally, the synthesis notes that juvenile salmon growth is influenced by water temperature and access to floodplain habitats – both of which are strongly related to flow.

2.5.1.5.1 Hydrologic Alteration

The natural flow regime of a water body is defined by its flow magnitude, timing, duration, frequency, and rate of change (Poff et al. 1997). Anthropogenic flow modifications are ubiquitous in running waters, and tend to be most aggressive in locations with highly variable flow regimes, like California, where water storage and flood control is most needed (Dudgeon et al. 2006). Across the major basins of California's Central Valley, mean monthly flows have been depleted at 80 percent or more of gages (Zimmerman et al. 2018). These changes in flow can have cascading effects that alter geomorphology (channel incision, widening, bed armoring, etc.) and connectivity (laterally with the flood-plain, longitudinal upstream-downstream, or vertically between surface water and groundwater) – ultimately impacting the chemical, physical, and biological properties of the ecosystem (Novak et al. 2016).

Literature reviews have shown that fish abundance, diversity and demographic rates consistently decline in response to both elevated and reduced flow magnitude (Poff and Zimmerman 2010). Changes in abundance in the Delta and estuary of juvenile Central Valley Chinook salmon appear related to flow (Brandes and McLain 2001) with recruitment in San Joaquin River Basin being highly correlated with the magnitude and duration of spring flows when the fish were sub-yearling juveniles (Sturrock et al. 2015). Studies in the Southern Sacramento-San Joaquin Delta observed that fish communities at each river location were consistently different each year, and correlated with river flow and turbidity (Feyrer and Healey 2003).

Flows may also be a migration cue for green sturgeon, so altered flows could impact adult in or out migration. Flows could also impact the number of deep pools in the river as well as those with specific characteristics (possibly including flow) that are necessary for spawning. Flow is also likely important for egg development and larval dispersal, but specific, appropriate flow rates are not determined. Reduced spring flows could negatively impact recruitment, given the likely relationship between high spring flows and high green sturgeon recruitment seen in 2006 (Heublein et al. 2017). Successful spawning in the Feather River has also been linked to high spring flows (2011 and 2017; (Heublein et al. 2017). Within the San Francisco Bay Delta Estuary, channel control structures, impoundments, and upstream diversions were recognized as specific threats that have altered and impacted juvenile and subadult/adult green sturgeon. The San Francisco Bay Delta Estuary environment has been highly impacted by structures built to divert water and by upstream impoundments, which have changed flow patterns, channel morphology, and water depth/presence and salinity in certain areas. Localized flow patterns can impact habitat quality for green sturgeon and flow may impact migration and movement.

2.5.1.5.2 Redd Dewatering

Redd dewatering is a risk to incubating salmonid eggs and alevin. Salmonid redds require cool, oxygenated, low turbidity water for approximately three to four months to complete the eggalevin life stages (Williams 2006). Water must move through a redd at a swift enough velocity to sweep out fine sediment and metabolic waste. Otherwise, incubating eggs do not receive sufficiently clean, oxygenated water to support proper development (Vaux 1968). Salmonid redd dewatering can occur when water levels decrease after redd construction, exposing buried and otherwise submerged eggs or alevins to air. Dewatering can affect eggs and alevins in multiple ways. Studies have shown that dewatering can impair egg and alevin development and cause direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (Reiser and White 1983, Becker and Neitzel 1985).

Because instream flows on the Sacramento River, Clear Creek, Stanislaus River, and American River are dependent on reservoir releases, redd dewatering can occur through water operations. On the Sacramento River, winter-run and spring-run are particularly susceptible to operational flow decreases when releases are reduced in the fall due to decreased water demands for irrigation and the need for Shasta-cold water storage conservation. Releases are further reduced in the winter to a minimum of 3,250 cubic feet per second (cfs), the amount depending on water year type and storage conservation needs, which may redd dewater Central Valley steelhead, fall-run, and late-fall run redds.

Dewatering of green sturgeon spawning areas is not a concern because of the location in which eggs are deposited and develop. green sturgeon spawning primarily occurs in cool sections of the upper mainstem Sacramento River in deep pools containing small to medium sized gravel, cobble or boulder substrate (Klimley et al. 2015a, Klimley et al. 2015b, Poytress et al. 2015). Sturgeon eggs primarily adhere to gravel or cobble substrates, or settle into crevices (Moyle 1995, Van Eenennaam et al. 2001, Poytress et al. 2015) where they incubate for a period of seven to nine days. Newly hatched sturgeon fry remain near the hatching area for 18 to 35 days prior to dispersing (Van Eenennaam et al. 2001, Deng et al. 2002, Poytress et al. 2015).

2.5.1.5.3 Redd Scour

Streambed scour resulting from high flows is a physical factor that can cause salmonid egg mortality. High flows can mobilize sediments in the river bed causing direct egg mortality, if scour occurs to the depth of the redd egg pocket. Scour can also increase fine sediment infiltration and indirectly decrease egg survival (DeVries 1997). Increased water releases for flood control, and for scheduled pulse flows for geomorphic benefit and salmonid migration cues, may be high enough to mobilize sediments, and scour Chinook salmon and steelhead redds.

2.5.1.5.4 Isolation and Stranding

Rapid reductions in flow can adversely affect fish. Juvenile salmonids are particularly susceptible to isolation or stranding during rapid reductions in flow. Isolation can occur when the rate of reductions in stream flow inhibits an individual's ability to escape an area that becomes isolated from the main channel or dewatered (U.S. Fish and Wildlife Service 2006). The effect of juvenile isolation on production of Chinook salmon and steelhead populations is not well understood, but isolation is frequently identified as a potentially important mortality factor for the populations in the Sacramento River and its tributaries (U.S. Fish and Wildlife Service 2001, Water Forum 2005, U.S. Bureau of Reclamation 2008, National Marine Fisheries Service 2009b, Jarrett and Killam 2014, Jarrett and Killam 2015).

Juveniles typically rest in shallow, slow-moving water between feeding forays into swifter water. These shallower, low-velocity margin areas are more likely than other areas to dewater and become isolated with flow changes (Jarrett and Killam 2015). Accordingly, juveniles are most vulnerable to isolation during periods of high and fluctuating flow when they typically move into inundated side channel habitats. Isolation can lead to direct mortality when these areas drain or dry up or to indirect mortality from predators or rising water temperatures and deteriorating water quality.

Isolation is currently a potential stressor in the upper Sacramento River, though mechanisms such as ramping restrictions exist that are intended to reduce the risk of occurrence. The upper Sacramento River has numerous side channel-like gravel bars that are used by juveniles as resting stops when inundated by higher flows. These areas can become isolated pools or even completely dewatered when reservoir releases are reduced. Although the NMFS 2009 Opinion (National Marine Fisheries Service 2009b) includes ramping restrictions for reservoir releases, CDFW rescues fish from these channel margin pools every year (California Department of Fish and Wildlife 2013b, 2015b, 2016b)(Azat 2018,). CDFW monitoring reports show a range of numbers of different species and runs of anadromous fish observed and rescued in these efforts. The dependence of isolation risk on factors such as rate of sediment mobilization, rate of sediment settling in channel margin areas, and timing and rate of flow reductions makes the quantification of stranding risk difficult.

2.5.1.5.5 Travel Time & Outmigration

Patterns of anadromous fish migration are influenced by a number of variables, including flow velocity, direction, volume, and source. When velocities along migratory corridors are reduced, juvenile outmigration takes longer and smolts are more likely to be vulnerable to increased predation risk (Anderson et al. 2005, Muthukumarana et al. 2008, Cavallo et al. 2013). The amount of time outmigrating juvenile salmonids spend traveling through migratory corridors in

the Delta is one indicator of predation risk, with longer travel time through the Delta often resulting in higher mortality rates.

Studies of Delta inflow and Juvenile Survival help to define the relationship of Sacramento River flow (at Freeport) and survival of juvenile salmon through the Delta, as well as the importance that fish migration routing has on migratory success. The acoustic tag studies (Perry and Skalski 2010, Perry et al. 2015, Perry 2016) indicate that survival probability increases with increasing flows, and changes in survival are steepest when flows are below 30,000 cfs at Freeport. The flow-survival relationship is strongest at lower flows, and in the reaches that transition from riverine to strong tidal influence. The relationship between flow and survival is in agreement with the assumptions and results of the velocity and entrainment analyses that indicated low, slack, and reverse velocities increase entrainment risk and increase travel time, which reduce survival probabilities. For example, entrainment into the interior Delta via Georgiana Slough or DCC is increased when flows in the mainstem Sacramento River are low, reversing, or stagnant, and the proportion of fish remaining in the Sacramento River or entering Sutter or Steamboat Slough are increased under high (Perry and Skalski 2010, Perry et al. 2015, Perry 2016). While the mechanisms causing reduced survival probabilities are likely combinations of reduced velocities, route selection, and increased entrainment into the interior Delta, the flow-survival relationship can be used to collectively evaluate effects of flow changes on through-Delta survival.

2.5.1.5.6 Delta Survival

There are two primary categories of effects in the south Delta due to water export: (1) salvage and entrainment at the south Delta export facilities, and (2) water-project-related changes to south Delta hydrodynamics that may reduce the suitability of the south Delta for supporting successful rearing or migration of salmonids and sturgeon from increased predation probability and exposure to poor water quality conditions. Key water-project-related drivers of south Delta hydrodynamics are Vernalis inflow, CVP and SWP exports from the south Delta export facilities, and the construction of the Head of Old River Barrier (HORB) or other agricultural barriers; these drivers interact with tidal influences over much of the central and southern Delta. In day-to-day operations, these drivers are often correlated with one another (for example, exports tend to be higher at higher San Joaquin River inflows) and regulatory constraints on multiple drivers may simultaneously be in effect. The Salmonid Scoping Team, a technical team associated with the Collaborative Adaptive Management Team (CAMT) process, evaluated how the relative influence of these drivers on hydrodynamic conditions varied temporally and spatially throughout the south Delta, [(Salmonid Scoping Team 2017b): Appendix B: Effects of Water Project Operations on Delta Hydrodynamics)]. In order to describe the driver-specific effects on south Delta hydrodynamics which are relevant to the types of operations anticipated in the PA, highlights of that report are provided below. The Delta flow regime can have effects on a wide range of factors such as productivity, food webs, or invasive species, and management actions related to CVP and SWP operations, which are just a few of many interacting drivers (Monismith et al. 2014, Delta Independent Science Board 2015).

Export effects in the south Delta are expected to reduce the probability that juvenile salmonids in the south Delta will successfully migrate out past Chipps Island, either via entrainment or mortality at the export facilities, or by changes to migration rates or routes that increase residence time of juvenile salmonids in the south Delta and thus increase exposure time to agents

of mortality such as predators, contaminants, and impaired water quality parameters (such as dissolved oxygen or water temperature). Effects of exports and HORB construction depend on location within the south Delta. For example, the HORB improves migratory conditions in the mainstem San Joaquin River but adversely impacts conditions in Old River if exports remain static with no concurrent reductions. Export effects of ongoing diversions from the south Delta export facilities adversely impact hydrodynamic conditions in the south Delta. If export diversions remain static with the HOR gate closed, the supply of water to maintain exports at the south Delta facilities must come from the channels to the north of the export facilities (i.e., Old River, Middle River, Columbia Cut and Turner Cut) which will increase flows towards the export facilities and thus make cumulative flows more negative. This reduces the likelihood of fish successfully migrating out of these channels should they be present, and increases the likelihood that fish from the mainstem San Joaquin River to the north that are entrained into these river channels by tides or other mechanisms will have a higher probability of moving southwards towards the export facilities under the influence of reverse flows.

Much uncertainty remains about how reach-scale hydrodynamic effects link to salmonid migration behavior in the south Delta. More data are available on both through-Delta survival and reach-scale survival for Chinook salmon and CCV steelhead. Recent reports summarize select data relevant to water-project-related effects on juvenile salmonid migration and survival in the south Delta (see in particular Appendices D and E of Volume 1 (Salmonid Scoping Team 2017a). These reports summarize the latest information on salmonid behavior and survival in the south Delta in the context of water project operations and so offer relevant information. Some overarching findings, summarized in Volume 1, are:

- Spatial variability in the relative influence of Delta inflow and exports on hydrodynamic conditions means that any given set of operational conditions may differentially affect fish routing and survival in different Delta regions.
- Gates and barriers influence fish routing away from specific migration corridors.
- The relationship between San Joaquin River inflow and survival is variable, and depends on barrier status and region of the Delta.
- Juvenile salmonid migration rates tend to be higher in the riverine reaches and lower in the tidal reaches.
- The extent to which management actions such as reduced negative OMR reverse flows, ratio of San Joaquin River inflow to exports, and ratio of exports to Delta inflow affect through-Delta survival is uncertain.
- Uncertainty in the relationships between south Delta hydrodynamics and through-Delta survival may be caused by the concurrent and confounding influence of correlated variables, overall low survival, and low power to detect differences.

The first four findings highlight that effects on routing and survival differ across the Delta and are sensitive to inflow and barrier status; as discussed earlier, the HORB effects tend to be positive on the mainstem San Joaquin River but negative in Old River mediated in part by the effect of inflow on tidal extent.

As described by National Marine Fisheries Service (2009b), entrainment of juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead at the south Delta export facilities may result in mortality. "Loss" is a term used to refer to the estimated number of fish that experience mortality within the export facilities, and is estimated based on the number of

salvaged fish (fish observed within the fish collection facilities at the export facilities) and a number of components related to facility efficiency and handling. Percentages refer to the percent of fish reaching a specific stage in the salvage process that are assumed to experience mortality during that stage. For example, the 75 percent loss associated with prescreen loss at the SWP means that 75 percent of the fish entering Clifton Court Forebay at the radial gates are assumed to die before reaching the primary louvers at the Skinner Fish Protection Facility. Of those fish that do reach the louvers, another 25 percent are lost, and so on. The total loss percentages represent the overall percent loss across all stages, that is, the percent of all fish entering the facility that die somewhere during the salvage process.

- SWP: (1) Prescreen loss (from Clifton Court Forebay radial gates to primary louvers at the Skinner Fish Protection Facility): 75 percent loss, (2) Louver efficiency: 25 percent loss; (3) Collection, handling, trucking, and release: 2 percent loss; (4) Post release: 10 percent loss; and (5) Total loss (combination of the above): 83.5 percent.
- CVP: (1) Prescreen loss (in front of trash racks and primary louvers): 15 percent loss; (2)
 Louver efficiency: 53.2 percent loss; (3) Collection, handling, trucking, and release: 2
 percent loss; (4) Post release: 10 percent loss; and (5) Total loss (combination of the above): 35.1 percent.

2.5.1.6 Entrainment

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), Entrainment was identified as a primary stressor affecting the recovery of the species. In the Recovery Plan Entrainment is defined as the redirection of fish from their natural migratory pathway into areas or pathways not normally used. Entrainment also includes the take, or removal, of juvenile fish from their habitat through the operation of water diversion devices and structures such as siphons, pumps and gravity diversions (National Marine Fisheries Service 2014b). While the former definition of Entrainment, the flow mediated Entrainment, is discussed in the previous section under Flow Conditions: Travel Time & Outmigration (2.5.1.5.5), and Delta Survival (2.5.1.5.6), here the discussion of the effects of Entrainment is limited to those associated with unscreened or inadequately screened water diversions. This threat primarily affects the juvenile rearing and outmigration life stage of these species, from the upper reaches of their watershed of origin through the Delta and Bays. Effects of the action that contribute to Entrainment are likely to result in a probable change in fitness of: reduced survival probability; or in cases where the PA would mitigate an unscreened or poorly screened water diversion the effect of the action would be to: increase survival probability.

The exact number of unscreened diversions in the Central Valley is not known as a recent assessment of water diversions has not been made. However, a dated but oft-cited assessment of water diversions in California's Central Valley identified 3,356 water diversions, 98.5 percent of which were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). And while quantification of the effect of small unscreened diversions is limited, there is no doubt that at times large numbers of juvenile salmonids are entrained by diversions, especially by large and small diversions on tributaries important for spawning and rearing (Moyle and Israel 2005). NMFS fish screen criteria (National Marine Fisheries Service 1997a, 2011e) intended to limit entrainment for waters which may contain salmonid fry (<60 mm in total length), identifies a maximum gap between bars of 0.069 in. (1.75 mm). Screens of these

dimensions are designed to minimize the entrainment of alevins, fry, juvenile, and larger salmonids. Juvenile fish with a head width of less than or slightly greater than 1.75 mm have the potential to pass through screen openings and get entrained into the diversions. It is possible that juvenile fish with heads larger than the 1.75 mm screen openings may pass through the fish screen if they become impinged on the fish screen and, during the process of trying to free themselves, change their orientation and are pulled through the fish screen openings by the current passing through the slot openings of the fish screen. Since ossification of the bones is not yet complete during the early life stages of teleost fish (Van den Boogaart et al. 2012, Mork and Crump 2015, Witten and Hall 2015), the plasticity of the cranium, opercular, and axial skeletal structures of larvae and fry may allow these otherwise bony structures to deform, allowing the fish to pass through a screen. Also, juvenile fish that exceed the minimum size criteria for exclusion and that are impinged on the fish screen may pass through the fish screen if they are pushed through by a screen cleaner brushes (ICF International 2015). It is expected that all fish entrained through a screen would be lost to the population, as an attempt to salvage any of these fish from behind the screens is not expected. These fish are effectively considered as mortalities, even if they survive their entrainment through the screens.

Impingement may occur when the approach velocity exceeds the swimming capability of a fish, creating substantial body contact with the surface of a fish screen. Whether or not impingement would occur depends on screen approach velocity, screen sweeping velocity, and the swimming capacity of juvenile fish. Injury resulting from impingement may be minor and create no longterm harm to the fish, or result in injuries leading to mortality either directly or at some time in the future after contact with the screen, including predation or infections from wounds and abrasions associated with the screen contact. Approach velocity is the vector component of the channel's water velocity immediately adjacent to a screen face that is perpendicular to and upstream of the vertical projection of a screen face, calculated by dividing the maximum screened flow by the effective screen area. Fish screens with approach velocities less than or equal to 0.33 ft/sec would minimize screen contact and impingement of juvenile salmonids (National Marine Fisheries Service 1997a). Sweeping velocity is the vector component of channel flow velocity that is parallel and adjacent to the screen face, measured as close as physically possible to the boundary layer turbulence generated by the screen face. Screening criteria from California Department of Fish and Game (2000) requires a sweeping flow velocity/approach velocity of 2:1 for in river fish screens while National Marine Fisheries Service (2011e) recommends that for screens longer than 6 feet, the optimal sweeping velocity should be at least 0.8 ft/sec and less than 3 ft/sec, with sweeping velocity not decreasing along the length of the screen. These criteria are such that they will reduce exposure time of fish to a screen and therefor the potential for impingement as fish move past it.

Historically, of the four Sacramento River Chinook salmon races, winter-run Chinook salmon have probably been the most vulnerable to entrainment because newly emerged fry would occur in the vicinity of water diversions during the July through August time periods of high agricultural diversion. However, juvenile emigration data suggest that peak winter-run Chinook salmon movement occurs in October and November, when pumping volume is decreasing or has ceased for the season. Fish screens, when meeting specific design criteria for screen materials, sweeping flows, and approach velocities described in the NMFS fish screen criteria (National Marine Fisheries Service 1997a, 2011e), have shown guidance efficiencies of greater than 98 percent for juvenile salmonids (i.e., less than 2 percent entrainment). In a field study of juvenile

salmonid injury and mortality related to contact with a vertical profile bar screen at John Day Dam (1.75 mm opening) resulted in an overall average of 2.5 percent for injury and 3.7 percent for mortality (Brege et al. 2005). These results likely represent the high end of juvenile fish injury and mortality rates at vertical profile bar screens.

For green sturgeon a study by Mussen et al. (2014a) indicated that juvenile green sturgeon (350mm mean fork length) appear to lack avoidance behavior when encountering unscreened waterdiversion structures. In this study sturgeon entrainment ranged from 26-61 percent and they estimated green sturgeon entrainment of up to 52 percent if they passed within 5 ft of an active diversion three times. The studies examined the rate of entrainment with different intake flows through the pipe inlet and sweeping flows past the unscreened diversions, where there did not appear to be significant differences in the entrainment risk at different sweeping velocities of 0.4, 1.2, and 2.0 ft/s. However, there was a trend towards less entrainment at higher sweeping flows, which appeared to be related to the swimming behavior of the experimental fish. At lower sweeping flows, fish were more actively swimming, and thus encountered the inlet to the pipe more frequently. In contrast, very low numbers of sturgeon were entrained in a monitoring project that sampled 12 unscreened diversions (<150 cfs) on the Sacramento River between Colusa and Knights Landing (Vogel 2013). During Vogel's study, green sturgeon were entrained at the South Steiner diversion during the irrigation seasons in 2010 (n=3 [extrapolated]; FL = 86 mm; approach velocity = 2.17 ft/sec) and 2011 (n=1; FL = 70 mm; approach velocity = 0.08ft/sec); and at the Tisdale diversion in 2011 (n=1; FL = 106 mm; approach velocity = 0.40 ft/sec) but not in the 2012 (n=0) irrigation season.

The multi-agency Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) synthesis teams also identified the relevant pathways by which *Entrainment* is likely to affect species as well as how it is likely to interact with other stressors. Windell et al. (2017) note survival across all life stages and in all geographic regions can be affected by entrainment, particularly within the rearing to outmigrating juveniles stage in the Upper and Middle Sacramento River and the Bay-Delta.

2.5.1.7 Loss of Riparian Habitat and Instream Cover

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), Loss of Riparian Habitat and Instream Cover was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration life stage of these species, from the upper reaches of their watershed of origin through the Delta. Effects of the action that contribute to the Loss of Riparian Habitat and Instream Cover are likely to result in a probable change in fitness of: reduced growth and/or reduced survival probability.

Loss of Riparian Habitat and Instream Cover refers to the process by which access to riparian habitat and instream cover is lost either by the construction of river features (i.e. levees, or flood control structures), or by river channelization due to the geological formation and controlled flow regimes that result in disconnection of the river from its historic floodplain. Construction of river features involves rip-rapping the river bank and removing vegetation along the bank and upper levees which removes most instream and overhead cover in nearshore areas. This has negative effects on riparian habitat due to the river's inability to naturally recruit riparian species seedlings as well as woody debris to deposit elsewhere. Woody debris and overhanging

vegetation within shaded riverine aquatic (SRA) habitat provide escape cover for juvenile salmonids from predators as well as thermal refugia. Aquatic invertebrates are dependent on the organic material provided be a healthy riparian habitat and many terrestrial invertebrates also depend on this habitat. Studies by the California Department of Fish and Game (CDFG) as reported in NMFS (National Marine Fisheries Service 1997b) demonstrated that a significant portion of juvenile Chinook salmon diet is composed of terrestrial insects, particularly aphids which are dependent on riparian habitat.

The multi-agency SAIL synthesis teams also identified the relevant pathways by which *Loss of Riparian Habitat and Instream Cover* is likely to affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) focused on the growth and condition of juveniles as being affected by access to riparian habitats. Habitats that provide refuge from high water velocity or predators, without depleting food supply, function to increase growth rates by reducing energy demand to obtain a given food supply. Growth rate may then, influence migration timing and success, where a higher growth rate is associated with earlier smoltification and faster downstream migration (Beckman et al. 2007). However, the inability of a juvenile in a particular habitat to supply its metabolic demand and achieve some threshold growth rate may also serve as a strong cue to leave that habitat and migrate downstream, and a satisfactory food supply may induce a juvenile to remain in the habitat for a longer duration of time to rear.

2.5.1.8 Loss of Natural River Morphology and Function

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), Loss of Natural River Morphology and Function was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration life stage of these species, from the upper reaches of their watershed of origin through the Delta. Effects of the action that contribute to the Loss of Natural River Morphology and Function are likely to result in a probable change in fitness of: reduced growth, reduced survival probability, reduced reproductive success, and/or reduced lifetime reproductive success.

Loss of Natural River Morphology and Function is the result of river channelization and confinement, which leads to a decrease in riverine habitat complexity, and thus, a decrease in the quantity and quality of juvenile rearing habitat. Additionally, this primary stressor category includes the effect that dams have on the aquatic invertebrate species composition and distribution, which may have an effect on the quality and quantity of food resources available to juvenile salmonids. For example, in a natural river system without one or more large dams, there is an upstream source of lotic aquatic invertebrate species available to juvenile salmonids, whereas on a river with a large terminal dam, the upstream drift of food resources to juvenile salmonids is drastically altered.

The multi-agency SAIL synthesis teams also identified the relevant pathways by which *Loss of Natural River Morphology and Function* is likely to affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) focused the impact of channelized, leveed, and riprapped reaches potentially having low habitat complexity, low abundance of food organisms, and offer little protection from predators – factors which juveniles are dependent for growth and successful survival.

Water depth modification caused by non-point source sediment was ranked in the Recovery Plan as a high threat to green sturgeon adults within the Sacramento River Basin and a medium threat to other life stages in the Sacramento River Basin. Impoundments and mitigation and restoration efforts were also considered as contributing to the water depth modification threat to all life stages in the Sacramento River Basin. Non-point source sediment includes runoff from urban areas, agriculture, forests, irrigated lands, landfills, livestock, mining operations, nurseries, orchards, etc. Removal of riparian vegetation results in increased erosion and input of fine grain material into the water. Sediment from these sources can be deposited in pools, green sturgeon requires deep pools for spawning and holding in the Sacramento River Basin. Large impoundments (e.g., Oroville, Shasta reservoirs) that reduce the frequency of high flow events may limit pool scouring and result in a reduction of pool depth. Survival and development of early life stages within the Sacramento River Basin may also be impacted by non-point source sediments through altered turbidity and substrate composition. At the time that the Recovery Team conducted its assessment, the High ranking for adults was attributed, in part, to the impact of water depth modification on the quantity and habitat quality of deep pools. The work of Mora (2016b) indicates 50-125 areas with greater than 5m depth available on the mainstem Sacramento River depending upon the year. It is uncertain as to whether all of these pools supply sufficient habitat for spawning and holding in terms of depth and substrate.

2.5.1.9 Loss of Floodplain Habitats

Loss of Floodplain Habitat and Loss of Wetland Function have been identified as primary stressors affecting the recovery of Central Valley salmonid species (National Marine Fisheries Service 2014b), and sDPS green sturgeon (National Marine Fisheries Service 2018g). This threat primarily affects the juvenile rearing and outmigration life stage of these species, from the upper reaches of their watershed of origin through the Delta. Effects of the action that contribute to the Loss of Floodplain Habitat are likely to result in a probable change in fitness of: reduced growth and/or reduced survival probability.

Although riverine floodplains support high levels of biodiversity and productivity, they are also among the most converted and threatened ecosystems globally (Opperman et al. 2010). In California, more than 90 percent of wetlands have been lost since the mid-1800s (Hanak et al. 2011, Garone 2011). Loss of Floodplain Habitat within the Central Valley is a result of controlled flows and decreases in peak flows which have reduced the frequency of floodplain inundation resulting in a separation of the river channel from its natural floodplain. Channelizing the rivers and Delta has also resulted in a loss of river connectivity with the floodplains that otherwise provide woody debris and gravels, that aid in establishing a diverse riverine habitat, and that provide juvenile salmonid rearing habitat.

The importance of connectivity for juvenile Chinook salmon to floodplain rearing habitat has been observed in several river systems. Research on the Yolo Bypass, the primary floodplain on the lower Sacramento River, indicates that floodplain are key juvenile rearing habitats supporting significantly higher drift invertebrate consumption and therefore faster growth rates (Sommer et al. 2001a, Katz et al. 2017). Otolith microstructure studies near the City of Chico recorded increased fall run Chinook Salmon growth, higher prey densities, and warmer water temperatures in off-channel ponds and non-natal seasonal tributaries compared to the main-channel Sacramento River (Limm and Marchetti 2009). Research of juvenile Chinook salmon on the Cosumnes River noted that ephemeral floodplain habitats supported higher growth rates for

juvenile Chinook salmon than more permanent habitats in either the floodplain or river (Jeffres et al. 2008). This growth is important to first year and estuarine survival, factors which may be key influences of a Chinook cohort's success (Kareiva et al. 2000).

As with other stressors the SAIL synthesis teams referenced the relevant pathways by which Loss of Floodplain Habitat could affect species as well as how it may interact with other stressors. However, instead of describing the negative effects caused by a Loss of Floodplain Habitat, Windell et al. (2017) examined the benefit of juvenile rearing on floodplains as it relates to survival, residence time and migration, and fish condition. The SAIL report notes the interaction with higher flows that activate accessible floodplains and secondary channels, which thereby expand the availability of low-velocity refuge habitat. The SAIL report also identifies inundated floodplains in the Central Valley as being particularly successful habitat for fish growth because it provides optimum water temperature, lower water velocity, higher food quality and density, and reduced predator and competitor density relative to the main channel (Windell et al. 2017).

2.5.1.10 Spawning Habitat Availability

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), *Spawning Habitat Availability* was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the spawning life stage of these species, in the upper reaches of their watershed of origin. Effects of the action that contribute to the *Spawning Habitat Availability* are likely to result in a probable change in fitness of: reduced reproductive success. One of the greatest threats to sDPS green sturgeon is the loss of spawning habitat due to the construction of dams in the Sacramento River system. Dams have limited available spawning habitats and, along with water management practices, have changed the flow and temperature profiles of the three major rivers that could be utilized by sDPS green sturgeon for spawning (i.e., Sacramento, Feather, and Yuba rivers).

Generally, successful spawning for Chinook salmon occurs at water temperatures below 60°F (National Marine Fisheries Service 1997b). Reiser and Bjornn (1979) report that upper preferred water temperatures for spawning Chinook salmon range from about 55°F to 57°F. The NMFS 2004 Opinion requires water temperatures to be maintained below 56°F in the upper Sacramento River above the RBDD (National Marine Fisheries Service 2004). The 56°F temperature criterion is measured as the average daily water temperature and as such, the criterion may allow water temperatures to exceed 56°F for some periods during a day. Chinook salmon spawn in riffles or runs with water velocities ranging from 0.5 to 6.2 ft/sec (Healey 1991, Vogel and Marine 1991). Spawning depths can range from as little as a few inches to several feet (Moyle 2002). Preferred water depths appear to range from 0.8 to 3.3 feet (Allen and Hassler 1986, Moyle 2002). Substrate is an important component of Chinook salmon spawning habitat, and generally includes a mixture of gravel and small cobbles (Moyle 2002). National Marine Fisheries Service (1997b) reports that preferred spawning substrate is composed mostly of gravels from 0.75 to 4.0 inches in diameter.

Spatially, the total area of viable salmonid spawning habitat has been significantly diminished. Physical features that are essential to the functionality of existing spawning habitat have also been degraded such as: loss of spawning gravel, and elevated water temperatures during summer months when spawning events occur (National Marine Fisheries Service 2014b). Degradation of

these features is actively mitigated through real-time temperature and flow management at Shasta and Keswick dams (National Marine Fisheries Service 2009b) as well as gravel augmentation projects in the affected area, which have been occurring under a multi-year programmatic authority (National Marine Fisheries Service 2015f). Current spawning is restricted to the mainstem and a few river tributaries in the Sacramento River (Myers et al. 1998). Naturally-spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (California Department of Fish and Wildlife 1998).

The multi-agency SAIL synthesis teams also identified the relevant pathways by which *Spawning Habitat Availability* is likely to affect species as well as how it is likely to interact with other stressors. Specifically, Windell et al. (2017) focused on egg survival, timing, and condition as being affected by spawning habitat, specifically sedimentation and gravel quantity. For green sturgeon the loss of access to historical spawning habitat and habitat degradation have largely restricted sDPS green sturgeon to one reach of the mainstem Sacramento River and made the population vulnerable to stochastic events (National Marine Fisheries Service 2018g).

2.5.1.11 Physical Habitat Alteration

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), *Physical Habitat Alteration* was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the spawning life stage of these species, in the upper reaches of their watershed of origin. Effects of the action that contribute to the *Physical Habitat Alteration* are likely to result in a probable change in fitness of: reduced reproductive success.

Physical Habitat Alteration includes loss of natural river morphology and function. Flood control measures, regulated flow regimes and river bank protection measures have all had a profound effect on riparian and instream habitat in the lower Sacramento River. Levees constructed in this reach are built close to the river in order to increase streamflow, channelize the river to prevent natural meandering, and maximize the sediment carrying capacity of the river (National Marine Fisheries Service 1997b). Additionally, nearshore aquatic areas have been deepened and sloped to a uniform gradient, such that variations in water depth, velocity and direction of flow are replaced by consistent moderate to high velocities. Gravel sources from the banks of the river and floodplain have also been substantially reduced by levee and bank protection measures. Levee and bank protection measures restrict the meandering of the river, which would normally release gravel into the river through natural erosion and deposition processes.

Chinook salmon spawn in clean, loose gravel, in swift, relatively shallow riffles, or along the margins of deeper river reaches where suitable water temperatures, depths, and velocities favor redd construction and oxygenation of incubating eggs. The construction of dams and resultant controlled flows and extensive gravel mining affect spawning habitat. Chinook salmon require clean, loose gravel from 0.75 to 4.0 inches in diameter for successful spawning (National Marine Fisheries Service 1997b). Juvenile Chinook salmon prefer slow and slack water velocities for rearing and the channelization of the river has removed most of this habitat type. The

construction of dams in the upper Sacramento River has eliminated the major source of suitable gravel recruitment to reaches of the river below Keswick Dam.

The threat of altered sediments to sDPS green sturgeon due to impoundments is high. The creation of upstream dams and impoundments can reduce sediment delivery to bays and estuaries. This can impact sDPS green sturgeon feeding habitat quality and quantity through changes in sediment deposition and composition and subsequent changes in prey resources or through changes in turbidity that could impact habitat use and predation by sight-predators.

2.5.1.12 Invasive Species/Food Web Disruption

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), *Invasive Species/Food Web Disruption* was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration life stage of these species through the Delta and Bays. Effects of the action that contribute to the *Invasive Species/Food Web Disruption* are likely to result in a probable change in fitness of: reduced growth and/or reduced survival probability.

Invasive species include both plants and animals, most of which have been introduced to the Delta unintentionally through ship ballast. However, some species have been introduced intentionally by resource agencies for sportfishing or forage. Invasive aquatic plants have become established in many areas of the Delta. Establishment of invasive aquatic plants can harm or kill native aquatic species because they form dense mats that block sunlight and deplete oxygen supplies. Most of these aquatic weeds were introduced to the Delta unintentionally and include water hyacinth (*Eichhornia crassipes*), hydrilla (*Hydrilla verticillata*) and egeria (*Egeria densa*). Within the Delta, the construction of levees and the conversion of adjacent riparian communities to other land uses have substantially changed the ecosystem. These changes have stressed native aquatic flora and fauna allowing infestation of invasive aquatic weeds. Invasive weeds flourish in the disturbed environment and may reduce foodweb productivity potentially harming fish and wildlife (CALFED Bay-Delta Program 2000).

The majority of clams, worms and bottom dwelling invertebrates currently inhabiting the Delta are non-native species. Non-native species also comprise an increasing proportion of the zooplankton and fish communities in the Bay-Delta system. It is estimated that a new non-native species is identified in the Bay-Delta every 15 weeks (CALFED Bay-Delta Program 2000). Many fish known to prey on juvenile anadromous salmonids were introduced by resource agencies to provide sportfishing. These fish include striped bass, American shad and largemouth bass. Although introductions have increased diversity in the Bay-Delta system, this increase in diversity has been at the expense of native species, many of which have declined precipitously or become extinct through predation and competition for resources (CALFED Bay-Delta Program 2000). At the same time, many non-native species are performing vital ecological functions such as serving as primary consumers of organic matter or as a food source for native fish and other wildlife populations (CALFED Bay-Delta Program 2000).

One of the most important habitat attributes of the riverbed to listed anadromous fish species in the action area is the production of food resources for rearing and migrating juveniles, such as drifting and benthic invertebrates, forage fish, and fish eggs. Benthic invertebrates, such as oligochaetes and chironomids (dipterans), are the predominant juvenile salmonid and sDPS green sturgeon food items produced in the silty and sandy substrates of the action area. Although

specific information on food resources for green sturgeon within freshwater riverine systems is lacking, they are presumed to be generalists and opportunists that feed on similar prey to other sturgeons (Israel and Klimley 2008), such as the population of white sturgeon present and coexisting with green sturgeon in the Sacramento basin. Seasonally abundant drifting and benthic invertebrates have been shown to be the major food items of white sturgeon in the lower Columbia River (Muir et al. 2000). As sturgeons grow, they begin to feed on oligochaetes, amphipods, smaller fish, and fish eggs as represented in the diets of white sturgeon (Muir et al. 2000).

Historically, the San Joaquin River has been an important source of nutrients to the Delta. Most of the San Joaquin River is now being diverted from the south Delta by CVP/SWP operations. The resultant loss in nutrients has likely contributed to an overall decrease in fertility of the Delta, limiting its ability to produce food (National Marine Fisheries Service 1997b). Additionally, pumping operations may result in a loss of zooplankton reducing their abundance in the Delta. Poor food supply may limit the rearing success of winter-run Chinook salmon. Extensive areas of the Delta are below mean high tide, but because of levees and flapgates installed throughout the Delta, these areas are no longer subject to tidal action. This effectively reduces the volume of water subject to tidal mixing and the size of the Delta floodplain. Reduced residence time of Delta water and associated nutrients restricts the development of foodweb organisms (CALFED Bay-Delta Program 2000).

The multi-agency SAIL synthesis teams (Windell et al. 2017) found predation by non-native species affected egg survival, timing, and condition and juvenile survival, residence time/migration, and growth.

2.5.1.13 Predation

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), *Predation* was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration life stage of these species, from the upper reaches of their watershed of origin through the Delta and Bays. Effects of the action that contribute to *Predation* are likely to result in a probable change in fitness of: reduced survival probability.

Predator-prey interactions can be broken down into several fundamental steps between the prey and the predator. These steps include the rates of encounters between the predator and the prey, the rate at which the predator decides to pursue and attack the prey when detected, the rate at which the predator successfully captures the prey, and, ultimately, the rate at which the prey is consumed by the predator. Each one of these steps is influenced by biological and physical factors in the surrounding environment such as prey abundance, spatial and temporal overlap of prey with the predator, habitat complexity, turbidity, and behavioral, physiological, and morphological adaptations that facilitate (predator success) or inhibit (prey avoidance) the predation process (Grossman et al. 2013, Grossman 2016). Although predation is frequently the proximate cause of mortality, the ultimate cause of mortality is often related to alterations in the physical or biological parameters of the habitat that prey occupy that enhance rate of predation. Because fish are highly adaptable, the response to habitat changes and quality are not always straightforward and linear and thus may not always be completely predictable, particularly on a shorter time scale. In general, though, habitat that is complex and offers a multitude of different

niches provides for a more diverse biological community (Grossman et al. 2013, Grossman 2016). In a stable, undisturbed, functioning habitat, multiple species can occupy the same general area by each species occupying a particular ecological niche, thereby minimizing direct competition between species and having a balanced predator-prey interaction. This is particularly true in habitats where predators and prey have co-evolved with each other. This relationship does not exist or is compromised when habitat is altered or nonnative species invade a new habitat, causing a loss of equilibrium among the species inhabiting it.

The Delta and Central Valley waterways are currently highly altered and disturbed habitats. In the aquatic ecosystems of the Central Valley and Delta waterways, widespread habitat alteration has occurred over the last 150 years. *Predation* is a threat to winter-run Chinook salmon, especially in the Delta where there are high densities of non-native fish (e.g., small and large mouth bass, striped bass, catfish, and sculpin) that prey on outmigrating salmon. The presence of man-made structures in the environment that alter natural conditions likely also contributes to increased predation by altering the predator-prey dynamics often favoring predatory species. In the upper Sacramento River, rising of the gates at the RBDD reduces potential predation at the dam by pikeminnow. In the ocean, and even the Delta environment, salmon are common prey for harbor seals and sea lions. Most of the predation on juvenile Chinook salmon in the Delta likely occurs from introduced species such as striped bass, black crappie, white catfish, largemouth bass and bluegill. Native Sacramento pikeminnow and steelhead also occur in the Delta and are known to prey on juvenile salmonids. Of these non-native predatory species, striped bass are likely the most important predators because: (1) the estimated abundance of striped bass in the Sacramento-San Joaquin system greater than 18 inches in length has ranged from about 600,000 to about 1,900,000 during the period between 1969 to 2005; (2) the total number of striped bass preying upon juvenile Chinook salmon in the system is greater than these estimated population sizes because striped bass smaller than 18 inches in length feed on juvenile Chinook salmon; (3) anectodal information indicates that striped bass movements up the Sacramento River coincide with juvenile Chinook salmon emigration, resulting in a co-occupancy of habitat; and (4) striped bass are opportunistic feeders, and almost any fish or invertebrate occupying the same habitat eventually appears in their diet (Moyle 2002).

The multi-agency SAIL synthesis teams also identified the relevant pathways by which *Predation* is likely to affect species as well as how it is likely to interact with other stressors. Windell et al. (2017) note survival across all life stages and in all geographic regions can be affected by predation, particularly within the egg to fry emergence stage, rearing to outmigrating juveniles stage in the Upper and Middle Sacramento River and the Bay-Delta, and ocean juvenile to ocean adult stage.

2.5.1.14 Hatchery Effects

During the development of the Recovery Plan for Central Valley Chinook Salmon and Steelhead (National Marine Fisheries Service 2014b), *Hatchery Effects* was identified as a primary stressor affecting the recovery of the species. This threat primarily affects the juvenile rearing and outmigration life stage of these species, from the upper reaches of their watershed of origin through the Delta and Bays. Effects of the action that contribute to *Hatchery Effects* are likely to result in a probable change in fitness of: reduced growth and/or reduced survival probability.

More than 32 million fall-run Chinook salmon, 2 million spring-run Chinook salmon, 1 million late fall-run Chinook salmon, 0.25 million winter-run Chinook salmon, and 2 million steelhead are released annually from six hatcheries producing anadromous salmonids in the Central Valley. All of these facilities are currently operated to mitigate for natural habitats that have already been permanently lost as a result of dam construction. The loss of this available habitat results in dramatic reductions in natural population abundance, which is mitigated for through the operation of hatcheries. During spawning, hatchery-and natural origin salmonids may compete for habitat, and interbreeding may reduce genetic integrity. Throughout juvenile rearing and outmigration, hatchery- and natural-origin salmonids may compete for habitat and food. When larger, juvenile, hatchery-origin steelhead are released into the river, they may predate on smaller natural-origin salmonids.

Recent biological opinion on the hatchery and genetic management plan for the Livingston Stone National Fish Hatchery (LSNFH) (National Marine Fisheries Service 2017b) identified hatchery impacts to ESA-listed species in the Central Valley, which include:

- 1) genetic impacts due to straying of hatchery fish and the subsequent interbreeding of hatchery fish with natural-origin fish
- 2) high harvest-to-escapements ratios for natural stocks. California salmon fishing regulations are set according to the combined abundance of hatchery and natural stocks, which can lead to over exploitation and reduction in the abundance of wild populations that are indistinguishable and exist in the same system as hatchery populations.
- 3) releasing large numbers of hatchery fish can also pose a threat to wild Chinook salmon and steelhead stocks through the spread of disease, genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks
- 4) in the ocean, limited marine carrying capacity has implications for naturally produced fish experiencing competition with hatchery production (Hatchery Scientific Review Group (HSRG) 2004). Increased salmonid competition in the marine environment may also decrease growth and size at maturity, and reduce fecundity, egg size, age at maturity, and survival (Bigler et al. 1996). Hatchery production may be in excess of the marine carrying capacity, placing depressed natural fish at a disadvantage by directly inhibiting their opportunity to recover (Northwest Power and Conservation Council 2003).

The multi-agency SAIL synthesis teams also identified some pathways by which Hatchery Effects is likely to affect species as well as how it is likely to interact with other stressors. Windell et al. (2017) state that high densities of hatchery salmon can negatively impact natural-origin juvenile populations that may be smaller in size and numbers by causing increased competition for food. Returning adult hatchery fish can affect natural-origin adult spawners by competition for habitat or genetic introgression, reducing genetic fitness in the wild populations.

2.5.2 Upper Sacramento/Shasta Division

During consultation for this Opinion, discussions between NMFS and Reclamation resulted in revisions to the PA that were not captured in the February 5, 2019, BA. Section 2.5.2.1-2.5.2.5 of the effects description below is based on the modeling associated with the February 5, 2019, PA (Appendix A1, the original PA) and associated modeling that NMFS requested. Section 2.5.2.6

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provides a supplemental effects analysis to assess the effects of the June 14, 2019, PA revisions reflected in the final PA (Appendix A3), including a discussion of whether and how the PA revisions modify the effects analyzed in Sections 2.5.2.1-2.5.2.5.

Reclamation operates the CVP Shasta Division for flood control, navigation, agricultural water supplies, municipal and industrial water supplies, fish and wildlife, hydroelectric power generation, Delta water quality, and water quality in the upper Sacramento River. Water rights, contracts, and agreements specific to the Upper Sacramento River, or that may dictate conditions therein include SWRCB Decisions 990, 90-5, 91-1, and 1641, Settlement Contracts, Exchange Contract, and Water Service Contracts. Facilities include the Shasta Dam, Lake [4.552 Million Acre Feet (MAF) capacity], and Power Plant; Keswick Dam, Reservoir, and Power Plant; and the Shasta Temperature Control Device. The Shasta Division includes the Red Bluff Pumping Plant, the Corning Pumping Plant, and the Corning and Tehama-Colusa canals, for the irrigation of over 150,000 acres of land in Tehama, Glenn Colusa, and Yolo counties. A description of the PA and the PA components affecting upper Sacramento River fish species is in Appendix A1. A depiction of the deconstructed action describing how the upper Sacramento/Shasta Division PA components relate to each other is provided in Figure 2.5.2-1. The primary stressors influenced by each PA component are identified in Table 2.5.2-1. A full description of each stressor, including the way in which the stressor would affect an individual's fitness, is found in Section 2.5.1 Stressors and Species Response. The exposure, risk, and response of each species to the projectrelated stressors are then analyzed in the following sections for each PA component.

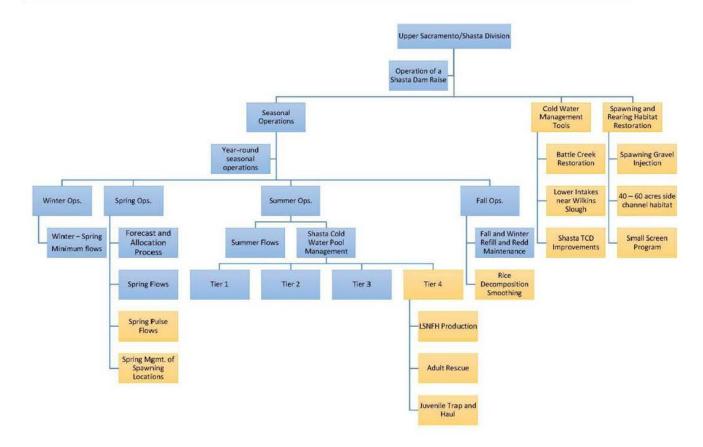


Figure 2.5.2-1. Deconstructed action describing the relation of project components in the Sacramento River. As provided in BA Table 4-6, blue action components were included in the PA as Core Operations and yellow action components were proposed as either Scheduling or subject to Collaborative Science, as stated in the BA.

Table 2.5.2-1. Primary stressors influenced by each Proposed Action component. Primary stressors are from the NMFS 2014 Recovery Plan for Central Valley Salmonids and NMFS 2018 Recovery Plan for sDPS of Green Sturgeon (National Marine Fisheries Service 2014, 2018).

Project Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Conditions	of Riparian Habitat Instream Cover	s of Natural River phology and Function	of Floodplain tat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
2.5.2.3.1.1 Winter Minimum flows	, Pa.	, Ha	X	, Wa	X Flow	X Loss	X Loss	X Loss	, Los	. Spo	, Phy Alt	, Invas	, En	, Pre	, Ha

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Project Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
2.5.2.3.2.2 Spring Base Flows		-	:=:	-	-	x	х	X		ī				-	*
2.5.2.3.2.3 Spring Pulse Flow	x	2	x	2	x	x	x	x	(M	127	2	9 2 8	24	7 <u>0</u>	받이
2.5.2.3.2.4 Spring Mgmt of Spawning Locations		æ	x	=	17	-	25.	æx		x	E	Ē	18	-	
2.5.2.3.3.1 Summer Cold Water Pool Management Tiers 1-4	ī	-	x	-			ž.		ï	ï	1	ž.	1	-	8
2.5.2.3.3 Delta Smelt Summer-Fall Habitat	ï	꼍	x	Έ	n=:	21	(A)	1811	24	3	Я	Į.	gi .	-	1211
2.5.2.3.4.1 Fall and Winter Refill and Redd Maintenance	150	5	200	=	X	X	X	i)	9	x	16	Ē	ы	353	Æ
2.5.2.3.4.2 Rice Decomposition smoothing (fall operations)	-		(-)	-	X	-	79 4 4	*	į	х	1	: E	4	-	-
2.5.2.4 Operation of a Shasta Dam Raise ⁹	-	22	848	2	-	2	©2.	<u>(18</u> 44)	æ	141	¥	(#	ä	-	받

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⁹ The PA proposes that operational criteria with the Shasta Dam Raise will be the same as operational criteria for the current dam and integrated CVP/SWP operations. Reclamation has advised NMFS that therefore the BA analyses suffice for purposes of consultation. There are no operational scenarios in the BA to evaluate to confirm beneficial or adverse effects of a raised Shasta Dam and NMFS therefore cannot further evaluate the Shasta Dam raise in this opinion.

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Project		120				0-	и								
Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
2.5.2.5.1.1 Battle Creek Restoration (Cold water pool management)	ï	_	2		2	x	-	,	1	x	1	ı	4	-	ĵ
2.5.2.5.1.2 Wilkins Slough Intakes (Cold water pool management)	-	3	x	ä	x	1	: -		ž		T.	3	x	-	(4)
2.5.2.5.1.3 Shasta TCD Improvements (Cold water pool management)	<u>(2)</u>	3	x	Ε	8	£	æ	8	14	ı	H	ì	3	-	8
2.5.2.5.2.1 Spawning Gravel Injection (Spawning/rearing habitat restoration)		-	=	-	e=	-	æ	=:	-	X	-		-	=	æ
2.5.2.5.2.2 Side-Channel Habitat Restoration (Spawning/rearing habitat restoration)	¥	2	-	-	-	X	u	3		-	-	¥	_	3 = 1	ů.
2.5.2.3.2.3 Small Screen Program (Spawning/rearing habitat restoration)		-	-	-		-		; • .:	-	-	-	*	x	-	
2.5.2.3.3.1 LSNFH Production (Tier 4 intervention)	82	2	121	-	70	27	10	(4)	- 1	Ψ.	-	227	2	2	X
2.5.2.5.3.3 Adult Rescue (Tier 4 intervention)	x		•	-	(5)	-		æx	:=	•		ú	X	-	
2.5.2.5.3.4 Juvenile Trap and Haul (Tier 4 intervention)	*	-	141	-	æ		: -	*:	:*	x	-	-	-	-	¥

2.5.2.1 Shasta Annual Operations

Reclamation operates Shasta and Keswick dams year-round in coordination with the other dams and reservoirs of the CVP and SWP. Seasonal operations follow a set of objectives. During winter, Reclamation operates for flood control and building storage, considering both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. When making flood control releases, Reclamation operates Shasta Dam to keep flows at Bend Bridge less than 100,000 cfs to protect populated areas downstream. This winter period can include significant flow fluctuations from Keswick Dam due to the flood control operations. During the winter and spring, when not operating for flood control, Shasta Dam is operated primarily to conserve storage while meeting minimum flows in the Sacramento River and to meet water quality and outflow requirements in the Delta. During the summer, Reclamation's operational considerations are mainly flows required for Delta outflows, instream demands, upstream temperature control, and exports. Fall operations attempt to maintain temperature control and provide for fish spawning habitat. Except for diversions needed for rice decomposition, downstream irrigation demands typically decrease during the fall, so during this time of year, Reclamation will operate to conserve storage and decrease Keswick releases.

On May 22, 2019, Reclamation met with NMFS to discuss the PA and reiterated their commitment to build storage in Shasta to improve overall storage relative to current operations. The PA includes several operational components, described in more detail in subsequent sections of this effects analysis, that Reclamation intends to implement to contribute to increased spring Shasta storage levels for the PA compared to recent years. These include (1) minimum late fall and winter flows, including modification of rice decomposition operations compared to the Current Operations Scenario (COS); (2) modified fall outflow requirements compared to the COS; (3) flexibility in export operations (especially in April and May) compared to the COS, and anticipated improved salinity conditions which would reduce carriage water demands; and (4) December 2018 changes to COA (which are also included in COS). Reclamation intends for these operations, as well as real-time operations, to aggregate and result in increased end of September carryover storage, which Reclamation expects to benefit the following May 1 storage in years that do not require flood control operations. Reclamation will use various operational flexibilities and/or contingency actions after May 1, potentially including adjusting initial allocations, to stay within a Tier, unless the change is caused by events outside Reclamation's control or beyond what was planned for in the temperature management plan.

2.5.2.1.1 Baseline and Without Action Considerations

It is clear to NMFS that Reclamation has endeavored to provide a PA that balances the needs of species, water supply, and other operational objectives and constraints. The sections below describe the specific seasonal components of the PA, their relation to the conceptual models describing species life histories, the effects of those PA components on identified stressors, and the subsequent effects to the species in the upper Sacramento River. In these subsequent sections, NMFS' goal is to trace effects of the proposed operations at Shasta Reservoir and to consider and analyze how the proposed daily, monthly, and seasonal operational decisions to store or release water, operate the temperature control device (TCD), complete restoration actions, and integrate Shasta operations with those of the Delta and other reservoirs have effects downstream on the species. Depending on the timing, location, lifestage, and species affected, these effects can be beneficial, neutral, or adverse, or all three based on which species is being evaluated. For

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example, a decision to store water in April has an adverse effect in April on CV spring-run Chinook salmon juveniles and a beneficial effect in May through October on winter-run Chinook salmon eggs and emergent fry. NMFS traces and analyzes these effects in this section of the Opinion, often in a comparative analysis relative to baseline conditions given the nature of modeling outputs and historical data. Our analysis culminates in an aggregate assessment with baseline effects in Integration and Synthesis section (Sections 2.8 and 2.9) to draw conclusions according to the ESA.

As discussed in Section 2.4 Environmental Baseline, the historical effects of dam construction and operations on the species are part of the environmental baseline, in addition to the past, present impacts of all Federal, State, or private actions and other human activities in an action area. The "without action" scenario provides context for how the existence of the CVP and SWP facilities have shaped the environmental baseline, including habitat conditions for species and critical habitat in the action area. In particular, the existence of the dams, an altered hydrograph, and high water temperatures limit access to suitable spawning habitat. A comparative analysis looking at changes in hydrographs helps to highlight the significant changes in flows that species experience from these historical conditions. The pre-dam hydrograph in Figure 2.5.2-2 shows that the median monthly flows would naturally have been quite different than the regulated flows into the upper Sacramento River since 1950. Demands and contract deliveries have created a peak in the hydrograph in May through August, with nearly minimum flows through winter, spring, and the rest of fall. In contrast, the natural hydrograph peaks during winter and spring months of December through May, which coincides with periods of increased precipitation and warmer-season snowmelt that are typical of the Central Valley climate.

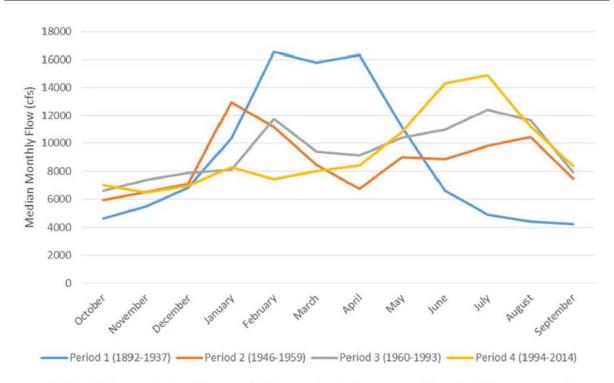


Figure 2.5.2-2. Hydrograph of median monthly flowrate in the Sacramento River for different pre- and postdam periods. Shasta Dam commission: 1944-1945; Keswick Dam commission: 1950. From Swart (2016).

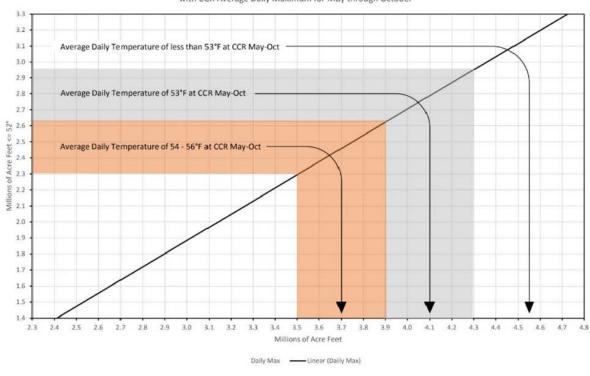
As introduced in Section 2.5.1 Species Stressors and Response, water temperatures significantly affect the distribution, health, and survival of native salmonids in the California Central Valley. Since salmonids are ectothermic (cold-blooded), their survival is dependent on external water temperatures and they will experience adverse health effects when exposed to temperatures outside their optimal range. Salmonids have evolved and thrived under the water temperature patterns that historically existed (i.e., prior to significant anthropogenic impacts that altered temperature patterns) in California Central Valley streams and rivers. Although evidence suggests that historical water temperatures exceeded optimal conditions for salmonids at times during the summer months on some rivers, the temperature diversity in these unaltered rivers provided enough cold water during the summer to allow salmonid populations as a whole to thrive (U.S. Environmental Protection Agency 2003).

Throughout year-round operations, physical processes drive relationships between flows, storage, cold water pool volume, and water temperatures (both lake and in-river). These relationships are driven by meteorology, precipitation, infiltration, runoff, and solar radiation, as well as Reclamation's actions and those of the water contractors included in the PA and all other diversions. Because of the thermal dynamics associated with seasonal stratification in Shasta Reservoir, Reclamation's decision concerning storage levels are linked to cold water pool volume availability and are primarily driven by hydrology, though meteorology also plays a role. As such, Reclamation's management of reservoir storage and operation of the temperature control device throughout the year impacts the availability of cold water and release

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temperatures and the subsequent thermal dynamics of the mainstem Sacramento River. Before the Shasta Dam TCD was built, NMFS required that a minimum 1.9 MAF end of September (EOS) storage level be maintained to protect the cold water pool in Shasta Reservoir in case the following year was critically dry (i.e., drought year insurance). This was because a relationship exists between EOS storage and the cold water pool. Especially for drier conditions, greater EOS storage level typically influences greater storage (and presumably cold water pool) in spring of the following year. Since 1997, when the TCD became operational, Reclamation has been able to use the TCD as an additional means to manage water temperatures in the upper Sacramento River.

It has also become apparent from Shasta operations in the drought years that an end of May storage requirement is a critical metric towards managing downstream temperatures during summer and early fall. While the ROC on LTO PA and communication with Reclamation (Field 2019) indicates that a minimum Shasta storage of approximately 3.66 MAF is necessary to access the upper gates of the TCD (Appendix A1, Table 4-7), Reclamation has stated (Field 2019) that a greater volume (approximately 3.9 to 4.1 MAF) is necessary to provide a high likelihood for operations to effectively blend water from the warmer upper reservoir levels and thereby reduce reliance on the more limited cold water. Figure 2.5.2-3 shows the general relationship between total storage, cold water pool storage, and summer/early fall downstream temperature that has been developed according to analysis done by Reclamation using data from 1998 through 2015 (Appendix A1, Figure 4-2). As this figure shows, an end of April storage between 3.9 and 4.3 MAF is needed to meet a daily average temperature of 53°F at the Sacramento River above Clear Creek gaging station in (CCR) May-October. This "rule of thumb" chart is used with temperature modeling of measured and forecasted conditions by Reclamation when developing temperature management plans.



Shasta Storage Vs 52°F or less Storage on May 1st with CCR Average Daily Maximum for May through October

Figure 2.5.2-3. Relationship between Temperature Compliance, Total Storage in Shasta Reservoir, and Cold Water Pool in Shasta Reservoir (ROC on LTO BA Figure 4-2).

Recent analyses can be useful to understand effects of changing the flowrate of reservoir releases, which is a method Reclamation considers for controlling temperatures below Shasta Reservoir. NMFS Southwest Fisheries Science Center (SWFSC) has analyzed the relationship between CCR water temperature and Keswick gauge (KWK) water temperature and discharge. Using observed mean daily flow and temperature values from 1998 to 2017, a linear model was fit to estimate the monthly relationship between increasing/decreasing flow or temperature at KWK and water temperature at CCR. The model allows prediction of the effect of a change in KWK discharge on CCR temperature, assuming a constant flow for a given month. Figure 2.5.2-4 shows the estimated KWK discharge temperature required to obtain a water temperature less than or equal to 53.5°F at CCR for five KWK discharge levels. Using this relationship of temperature and flow, it is possible to estimate either the minimum flowrate or the maximum release temperature at KWK that is required to maintain 53.5°F at CCR in a particular month.

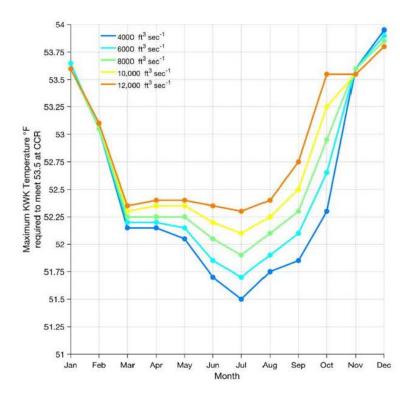


Figure 2.5.2-4. Estimated KWK discharge temperature required to obtain a water temperature less than or equal to 53.5°F at CCR for five KWK discharge levels.

The recent California drought provides experience to consider in summer temperature management. The critically dry water year of 2014 was followed by a dry 2015, which deepened the drought in California. An already low initial cold water pool (CWP) volume increased the difficulty of providing suitable cold water temperatures for successful egg and alevin incubation in 2015. In 2015, the Drought Exception Procedures of RPA I.2.3.C of the NMFS 2009 Opinion was triggered. Specifically, the February forecast, based on 90 percent hydrology, showed that a Clear Creek temperature compliance point or 1.9 MAF EOS storage was not achievable. During the development of the temperature management plan (TMP), there were regular and frequent check-ins on the status of the CWP, storage levels, and temperatures, along with a suite of operational scenarios and Keswick release schedules, which were evaluated by the Sacramento River Temperature Task Group (SRTTG) for recommendation to Reclamation. As more information was obtained about the current and developing condition, additional operational scenarios were considered and evaluated, including changes to the amount of storage gained or lost with each Keswick release option, release temperature, and flow rate necessary to meet downstream temperatures while attempting to meet downstream obligations. Figure 2.5.2-5 is a temperature landscape profile over space and time for the five scenarios under consideration in 2015 compared to 2014.

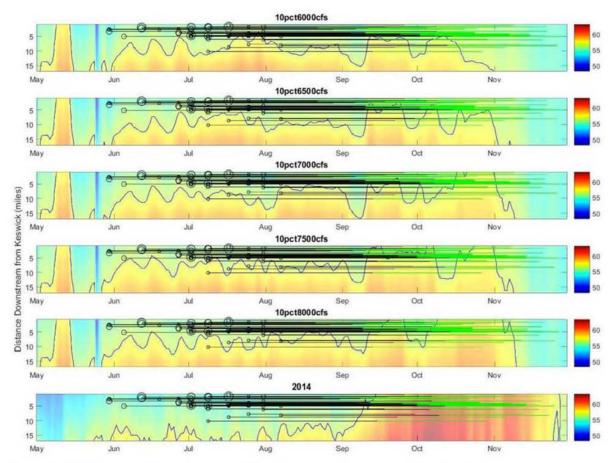


Figure 2.5.2-5. Temperature landscape profiles of the upper Sacramento River for the five scenarios evaluated for 2015 compared to conditions of 2014. The isoline shows 57°F. The circles indicate 2014 redd timing and location. The black represents winter-run egg and alevin development time in the gravel. The green line represents the fry rearing phase. The y-axis indicates miles of downstream habitat suitable for rearing juvenile winter-run among the different flow scenarios.

2.5.2.1.2 Project Uncertainties

NMFS has identified sources of uncertainty, which are identified in Table 2.5.2-2, that are considered in the evaluation of effects of the PA components for the upper Sacramento/Shasta division. Table 2.5.2-2 includes uncertainties related to modeling limitations, alternative analytical tools, and real-time implementation of the PA, noting the information provided by Reclamation, and the assumption we have applied in addressing the uncertainty.

Table 2.5.2-3 provides a comparison of key current operations to the proposed operations of the PA to describe the differences in project components and sources of uncertainty. Reclamation identifies the PA components as being different from the current operations in terms of temperature management, spring pulse flows, fall base flows, and increased production at LSNFH. There are, however, additional changes to current operations that are part of the PA, but which are not explicitly identified in the BA. NMFS has identified these changes through our own evaluations of the PA modeling, review of historical information, and exchange of

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information with Reclamation. We identify those changes in the table below, and we trace the extent of effect of these changes, noting the level of uncertainty regarding Reclamation's operations effects on flows, storage, and temperatures.

Table 2.5.2-2. Sources of uncertainty associated with analysis of the PA operations of Shasta Dam and the upper Sacramento River.

	I:	
Source of Uncertainty	Information from BA and Supplemental Reclamation Submissions	How NMFS Applied Assumptions to Address Uncertainty
Physical Modeling of the Proposed Action and Current Operations Scenario	The COS does not explicitly include the storage components of the RPA of the NMFS 2009 Opinion due to limitations in CalSimII model capability.	COS may not explicitly meet historical storages due to the real-time operations and short-term modifications within the entire system. The model creates shortages based on water supply including conservative forecasts of inflow. There are limitations to applying CalSimII storage results in a comparative manner to determine the expected impact of the proposed action.
	Years are considered to be within Tier 1 despite exceedances of 53.5°F daily average temperature in over 20 percent of modeled days; PA assumes that real-time operations will allow avoiding exceedances.	NMFS considers that the biological response that fish experience may not exactly achieve 53.5°F, or as described in other tiers. NMFS assumes that Reclamation's operational flexibility will minimize the frequency and magnitude of exceedances that would compromise the objective of the given Tier (Note: pending additional analysis from Reclamation to support this conclusion).
	Climate change is incorporated using CMIP3 and AR3, which does not reflect best available science for temperature increases.	Assumed that the provided modeling represents a scenario of limited effects of climate change to the species; NMFS layers additional qualitative evaluations onto quantitative analyses to reflect greater projected changes in temperature and sea level rise in CMIP5 modeling.
Biological Modeling	Anderson (2018) model simulates egg to hatch through life stage-dependent temperature mortality and the spatially dependent background mortality from hatch through fry stages. The Anderson model assumes that redds/eggs are most sensitive to DO conditions during the five days preceding hatch and results include mortality only for that period.	In considering differences between results from the Anderson and Martin models, NMFS considers that the Anderson model could underestimate mortality by not accounting for egg mortality prior to the hatch period in the percentage mortality during the hatch period. Results for both models are considered in the effects analysis.

Source of Uncertainty	Information from BA and Supplemental Reclamation Submissions	How NMFS Applied Assumptions to Address Uncertainty
	Anderson model is based on previous (Rombough 1994) analyses, but has not completed a peer-review process.	Considered external reviews and field-testing in discerning weight of evidence applied to methods according to categories identified in Section 2.1 Analytical Approach. Acknowledges the uncertainties and needs for additional research identified in review of Martin et al. (2017) but also that it is a "parsimonious and realistic representation of temperature effects on eggs" (Gore et al. 2018).
Uncertainty During Real- Time Implementation of Proposed Action	Annual and seasonal uncertainties with precipitation and runoff, air temperatures, and cloud cover.	NMFS considers that the biological response that fish experience may not exactly achieve that of 53.5°F, or as described in other tiers.
	Uncertainty about forecasted TCD performance.	NMFS considers that the biological response that fish experience may not exactly achieve that of 53.5°F, or as described in other tiers.
	Assumptions about operational precision, human error, and unanticipated events (e.g., Carr fire, North American Electric Reliability (NERC) testing).	NMFS considers that the biological response that fish experience may not exactly achieve that of 53.5°F, or as described in other tiers.
	Assumptions about actual accretions and depletions in upper Sacramento River may not be accurate, especially during dry hydrology/drought.	NMFS considers that the biological response that fish experience may not exactly achieve that of 53.5°F, or as described in other tiers.

A specific example of uncertainty related to real-time implementation of the PA is the exposure risk to temperature conditions during summer temperature management. While the BA describes an approach to summer temperature management, the PA does not include a process by which it would achieve any defined metric. NMFS must, therefore, include in our analysis the uncertainty of achieving any threshold storage level that dictates summer temperature management as defined in the BA for a specific Tier. For current operations, Reclamation takes a conservative approach to building storage that starts by targeting minimum flows in the fall and winter until either the reservoir nears the flood control elevation or another requirement, such as Delta water quality, requires increased releases of stored water. With this approach, Reclamation develops a monthly Keswick release forecast using the Shasta EOS carryover storage and various historical hydrologies. The current operations include an interagency workgroup that provides input to Reclamation on taking additional actions, including export curtailments, if necessary, to conserve storage and other protections/measures. Similarly, for the PA action component Fall and Winter Refill and Redd Maintenance (Section 2.5.2.3.4.1), Reclamation is proposing to set minimum fall flows according to Shasta EOS carryover storage. The operations of the PA intend to remove the

uncertainty that results from advisement offered by an interagency workgroup, but NMFS recognizes that winter and spring flows could be controlled by other requirements and, therefore, above the minimum flows identified to achieve adequate storage to provide cold water releases for winter-run Chinook salmon in the following year.

Based on conversations during May 20-24, 2019, NMFS assumes that Reclamation will coordinate under all conditions, and seek technical assistance from NMFS and the USFWS regarding species intervention measures (Section 2.5.2.5.3 Intervention Measures) only in the driest of the four proposed Tiers (i.e., March 90 percent exceedance runoff forecast indicate May 1 Shasta storage of less than 2.5 MAF). In contrast, the existing process includes monthly consultations between NMFS and Reclamation from the February forecast through the issuance of the Sacramento River temperature management plan in May. These consultations provide NMFS with the opportunity to provide information regarding biological criteria for spring operations of Keswick Dam releases, with the intent of reducing negative effects of increased temperature on winter-run Chinook salmon while still accommodating other legal and delivery requirements. The only similar coordination process included in the ROC on LTO PA occurs when storage is forecasted to be below 2.5 MAF at the beginning of May.

Furthermore, NMFS notes that analysis will include effects of deliveries to all CVP contractors, including implementation and performance of the north-of-Delta settlement contracts. Therefore, we evaluate the full effects of maximum water deliveries and diversions under the terms of existing contracts and agreements, including timing and allocation in this Opinion, as well as other obligations, including D-1641, refuge supplies, and exchange contractor deliveries.

NMFS notes that, in comparison to current operations, the effects of which are considered part of the baseline, the PA does not include an EOS carryover storage performance measure, which would be especially helpful in providing future protections for back-to-back dry years. According to the PA, fall, winter and spring reservoir releases are based on a Shasta EOS storage; however, the PA does not propose any particular end of September storage target. NMFS has evaluated the effects of reservoir operations according to the project description and the modeling results provided in the BA.

In a comparative analysis, and with regards to the characterization of operations since 2009, the COS, and the PA in the physical modeling, NMFS used Table 2.5.2-3 to better understand the comparative results of the PA versus the COS and the accuracy of COS in characterizing current operating criteria. While the COS is intended to represent the current operating criteria (i.e., operations that comply with the USFWS 2008 and NMFS 2009 opinions), the COS does not include year-specific adjustments, modified drought requirements, maintenance of facilities, facility malfunctions, or other short-term or unforeseen actions that change real-time operations. NMFS has identified ways in which the COS CalSimII modeling deviates from a description of actual current operations. There are, therefore, ways in which the COS does not fully characterize the historical operations of the last 10 years under the NMFS 2009 Opinion. Modeling for the COS does not explicitly prioritize releases from Folsom and Oroville reservoirs (rather that Shasta releases) per specific RPA elements to meet in-Delta water quality or flow requirements, though it does consider relative reservoir storage when determining releases for in-Delta needs. For the purposes of comparing the PA to current operations, NMFS has assessed effects of building storage relative to coordinated use of Oroville releases. Additionally, the COS model does not reflect management options to limit Keswick releases to 7,500 cfs or less in July

of dry and critical years, and the model is not capable of characterizing particular temperature operations or the ability to change temperature targets throughout the year. All of these actions have the potential to result in increased coldwater pool in Shasta Reservoir in the spring period. NMFS has used this information in better understanding the resulting comparisons of Shasta Reservoir storage for the PA versus the COS and placing that in context given conditions and operations in the last decade.

To address uncertainty regarding these components, NMFS has developed a memorandum to the ROC on LTO administrative record that evaluates various lines of evidence, including the CalSimII modeling of Shasta storage (from the ROC on LTO BA Appendix D), historical evaluation of Keswick flowrates, and CalSimII Modeling of Drivers of Shasta Releases. Based on this evaluation, NMFS still has notable uncertainty that Reclamation's operations allow the ability to considerably increase the total Shasta storage on May 1 for the PA. However, we acknowledge that what may seem like a minor increase – if operations and other constraints allow for it to occur – for the PA can be valuable in augmenting available cold water pool volume if that increase occurs with the ~1 MAF operating range of the total volume range. This increase could allow better access to the upper gates earlier in the year, which could contribute to better temperature management.

Table 2.5.2-3. Comparison of the current operations to the Proposed Action for major CVP action components.

Action Component	Actual Current Operation	Characterization in Modeling of Current Operations Scenario (COS)	Inclusion in Proposed Action (PA)
Spring Actions	NMFS RPA Action I.2.3 February forecast; March-May 15 Keswick Release Schedule (Spring Actions): Consultation prior to initial water allocations Review of temperature modeling Conserve storage.	None.	None.
Spring Pulse Flows	None.	None.	Spring pulses if projected May 1 storage > 4 MAF: up to 150 TAF limit but not if it: interferes with the ability to meet other anticipated demands on the reservoir would cause Reclamation to drop into Tier 4.

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Action Component	Actual Current Operation	Characterization in Modeling of Current Operations Scenario (COS)	Inclusion in Proposed Action (PA)		
Summer Cold Water Pool Management	NMFS RPA Action I.2.4: May 15 through October Keswick Release Schedule, Shasta Temperature Management, WRO 90-5 downstream temperature targets. Recent (last 3 years) operational study of 53.5°F daily average temperature at CCR In real time, may end after last winter-run Chinook salmon redd emerges, as advised by SRTTG.	No direct temperature criteria.	Temperature management based on use of Shasta cold water pool for winter-run survival, including WRO 90-5, by implementing 1 of 4 tiers with provisions: • Tiers can switch within a year • Tiers are selected at the beginning of May unless the March forecast shows a potential for Tier 4. • Temperature management starts after May 15 or when there is evidence of winter-run spawning • Temperature management ends October 31, or 95 percent winter-run Chinook salmon emergence, whichever		
	NMFS RPA Action I.2.1: performance measures (Note: these are not prescribed targets that drive operations): • End of September carryover storage; and • Temperature compliance point locations.	No direct carryover storage criteria and therefore no Shasta storage performance measures are in the model. The model has a combination of water-related goals and constraints that results in a September Shasta storage frequency that approximates the 2009 performance measures.	None.		
Fall and Winter Refill and Redd Maintenance	NMFS RPA Action I.2.2 November through February Keswick Release Schedule: various requirements and input from interagency workgroup and Keswick releases for EOS carryover storages >2.4 MAF, 1.9- 2.4 MAF, and drought.	The CalSimII model does not include (b)(2) related logic/accounting. The high frequency of precipitous drops in the COS Keswick releases in December do not accurately reflect current operations.	Measures to reduce fall-run redd dewatering and rebuild cold water pool, e.g., when EOS storage is: ≤ 2.2 MAF, flow is 3,250 cfs; ≤ 2.8 MAF, flow is 4,000 cfs; ≤ 3.2 MAF, flow is 4,500 cfs; > 3.2 MAF, flow is 5,000		

Action Component	Actual Current Operation	Characterization in Modeling of Current Operations Scenario (COS)	Inclusion in Proposed Action (PA)
x	NMFS RPA Action I.2.5: Winter-run passage and reintroduction program above Shasta Dam.	None.	None.
Conservation Interpretation Livingston Stone National Fish Hatchery.		None.	Increased use of Livingston Stone National Fish Hatchery during droughts.

2.5.2.2 Conceptual Models and Stressor Linkages

To link PA components to the potential effects to the species and the species life-stage, NMFS uses the SAIL conceptual models (Windell et al. 2017), which describe the physical and biological drivers affecting the particular life-stage and life-stage transitions of winter-run Chinook salmon. The Sacramento River provides spawning, rearing, and migratory corridor habitat for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon, and similar conceptual models can apply to all of these anadromous fish species. With these models, NMFS is able to identify the PA components, the influence of those components on environmental drivers, and the habitat attributes and species response affected by changes in the environmental drivers. The environmental drivers and habitat attributes described by Windell et al. (2017) are also explicitly linked to the primary stressors affecting the species identified in the respective recovery plans (National Marine Fisheries Service 2014b, 2018g). Those stressors and their linkage to the recovery plan provide a reference for the severity of their effect on the species and how they may hinder or contribute to the recovery of the species.

For the upper Sacramento River (Keswick Dam to RBDD), the first SAIL conceptual model (CM1) defines the egg incubation and alevin development stage as the duration of eggs in a redd to the emergence of fry (Windell et al. 2017). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage are described in Figure 2.5.2-6, where the stars indicate factors that are directly influenced by management actions (n.b., the Tiers in the figures from Windell et al. 2017 are not the same as the operational Tiers included in the Summer Cold Water Pool Management component of the PA; they are common in terminology only). In this case, management actions are understood to have an influence on Shasta and Trinity reservoir storage/hydrology, Keswick releases/flow, in-river fishery/trampling, and substrate size. For the life stages described in CM1, the attribute and driver of Shasta and Trinity storage/hydrology and Keswick releases likely contribute to the water temperature, flow conditions, spawning habitat availability, and predation stressors affecting recovery. The in-river fishery/trampling habitat attribute relates to the harvesting/angling impacts stressor, and the substrate size habitat attribute is a component of the spawning habitat availability stressor.

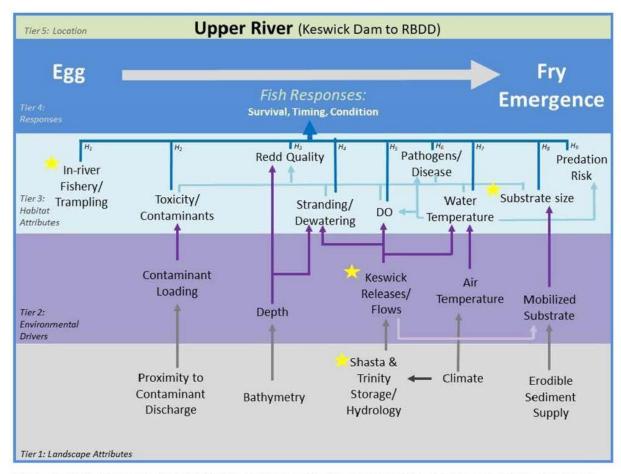


Figure 2.5.2-6. Conceptual model (CM1) of drivers affecting the transition of winter-run Chinook salmon from egg to fry emergence in the Upper Sacramento River (From Windell et al. 2017). The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Also applicable to the upper Sacramento River (Keswick Dam to RBDD), the second SAIL conceptual model (CM2) defines juvenile rearing in this reach as the period from emergence as fry to juvenile migration past RBDD (Windell et al. 2017). The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 2.5.2-7, with stars indicating factors and pathways that are hypothesized to be influenced by management actions. These include Shasta and Trinity storage/hydrology, contaminant loading, fish assemblages, and Keswick release/flows and irrigation diversions. For the life stage described in CM2, the attribute and driver of Shasta and Trinity storage/hydrology and Keswick releases likely contribute to the water temperature and flow conditions stressors affecting recovery.

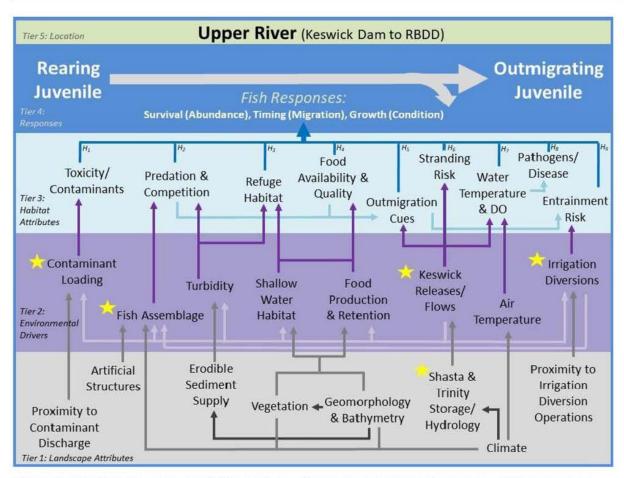


Figure 2.5.2-7. Conceptual model (CM2) of drivers affecting the transition of winter-run Chinook salmon from juvenile rearing to outmigration in the Upper Sacramento River (from Windell et al. 2017). The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

The third SAIL conceptual model (CM3) defines juvenile rearing in the middle Sacramento River (RBDD to Sacramento, including Sutter and Yolo Bypass) as the period starting with juvenile migration past RBDD until juveniles migrate past the I Street Bridge in Sacramento. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 2.5.2-8. During this period, the factors and pathways that are hypothesized to be influenced by management actions include contaminant loading, fish assemblages, floodplain connectivity, flows/tributary reservoir releases, and water diversions/agricultural irrigation. For the life stage described in CM3, the attribute and driver of floodplain connectivity likely contributes to the loss of natural river morphology and function stressor affecting recovery. The driver of flows/tributary reservoir releases and water diversions/agricultural irrigation likely contribute to the passage impediments/barriers to migration and water temperature stressors affecting recovery.

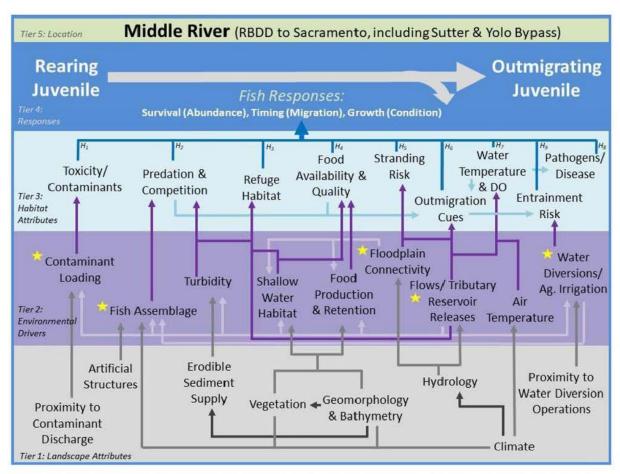


Figure 2.5.2-8. Conceptual model (CM3) of drivers affecting the transition of winter-run Chinook salmon from juvenile rearing to outmigration in the Middle Sacramento River (from Windell et al. 2017). The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

The sixth SAIL conceptual model (CM6) defines adult migration through the Sacramento River (San Francisco Bay to Keswick Dam) as the period starting with adult migration from the ocean to Keswick Dam in the Upper Sacramento River. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 2.5.2-9. During this period, the factors and pathways that are hypothesized to be influenced by management actions include flood bypass weirs, Shasta and Trinity storage/hydrology, inriver fishery/poaching, and Keswick releases/Colusa Basin releases/flows. For the life stage described in CM6, the attributes and driver of Shasta and Trinity storage/hydrology, Flood Bypass Weirs, and Keswick releases/Colusa Basin Releases/Flows likely contribute to the water temperature, flow conditions, and spawning habitat availability stressors affecting recovery. The in-river fishery/poaching habitat attribute relates to the harvesting/angling impacts stressor.

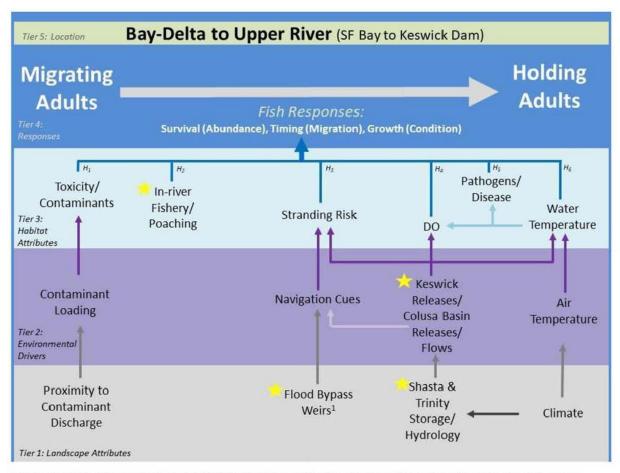


Figure 2.5.2-9. Conceptual model (CM6) of drivers affecting the transition of adult winter-run Chinook salmon from the ocean to the Upper Sacramento River (from Windell et al. 2017). The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

The last SAIL conceptual model relevant to the Upper Sacramento/Shasta Division (CM7) defines adult holding to adult spawning in the Upper Sacramento River (Keswick Dam to RBDD) as the period starting with adult migration past RBDD until spawning. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are described in Figure 2.5.2-10. During this period, the factors and pathways that are hypothesized to be influenced by management actions include the hatchery broodstock program, Anderson-Cottonwood Irrigation District (ACID) Dam, Shasta and Trinity storage/hydrology, gravel quality & distribution/augmentation, Keswick releases/cold water storage/flows, and inriver fishery/poaching. For the life stage described in CM7, the attributes and driver of Shasta and Trinity storage/hydrology, TCD operations, and Keswick Releases/Cold Water Storage/Flows likely contribute to the water temperature, flow conditions, and spawning habitat availability stressors affecting recovery. ACID and Gravel Quality and Distribution/Augmentation relate to spawning habitat availability, while the in-river fishery/poaching habitat and hatchery broodstock program attributes relate to the harvesting/angling impacts and hatchery effects stressors, respectively.

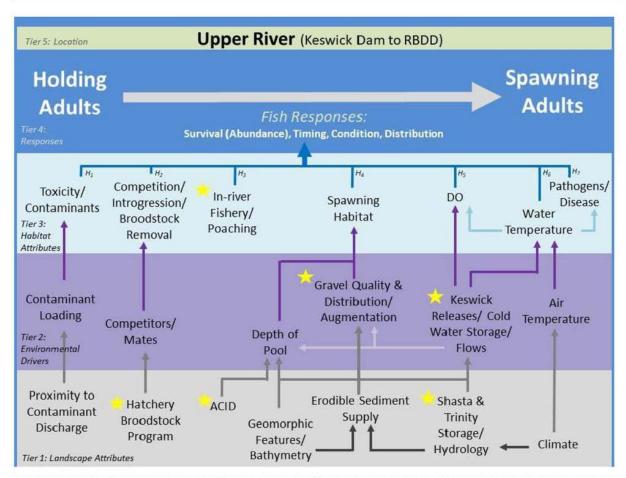


Figure 2.5.2-10. Conceptual model (CM7) of drivers affecting the transition of holding to spawning for adult winter-run Chinook salmon in the Upper Sacramento River (from Windell et al. 2017). The stars indicate factors and pathways that are hypothesized to be influenced by management actions.

Figure 2.5.2-1 shows the conceptual deconstruction of the action for the Shasta Division, which is informative in describing further the relationships between various processes and outcomes. PA components that reduce in river flows such as the Winter Minimum Flows (Section 2.5.2.3.1.1) help to build Shasta storage, which increases the likelihood of meeting temperature targets in-river/below dams in the summer as part of Summer Cold Water Pool Management (Section 2.5.2.3.3.1). Likewise, PA components that increase seasonal flows, such as releases to support the diversion of water supplies under contracts (Section 2.5.2.3.2.1) and meet other requirements in the Delta, can reduce storage and the likelihood of meeting summer temperature requirements.

Sometimes this relationship is explicit in the PA and BA analysis, as seen in Section 2.5.2.3.4.1 Fall and Winter Refill and Redd Maintenance, where Reclamation proposes to set the Keswick Dam fall release schedule based on Shasta EOS storage. In this case, Reclamation is proposing a range of Keswick releases and fall flows that are defined by Shasta EOS storage; higher EOS storage corresponds to higher fall flows because the need to actively build storage in the fall is relaxed. Other parts of the PA do not propose to manage to explicit metrics, such as flows or

storage targets. In these instances, for the purpose of analysis, NMFS has made conservative assumptions about the actions Reclamation may take to meet assumed operational targets (Table 2.5.2-2). We document our applied assumptions, many of which were discussed with Reclamation during technical assistance for this consultation, at appropriate points throughout our analysis. In keeping with the principle of institutionalized caution, our analysis and assumptions generally give the benefit of the doubt to the species where there is uncertainty.

2.5.2.3 Upper Sacramento/Shasta Division Project Components Analysis

2.5.2.3.1 Shasta Winter Operations

From December to February, Reclamation operates primarily for flood control and storage conservation, where the upper limit of operations is constrained by both the channel capacity within the Sacramento River and Shasta Reservoir flood conservation space. During this season and into the spring period there are accretions (flows from unregulated creeks and other unmeasured sources) into the Sacramento River below Keswick Dam. These local accretions help to meet both instream demands and outflow requirements, minimizing the need for additional releases from Shasta and Folsom reservoirs. In wetter year types, Reclamation may be able to operate mostly to target flood control and minimum instream requirements because of the large volumes of accretions in the Sacramento River. In drier years, these accretions may be lower and, therefore, require increased releases from the upstream reservoirs to meet state permit requirements and minimum health and safety exports in the Delta.

2.5.2.3.1.1 Winter Minimum Flows

Reclamation proposes to set target base flows from Keswick Dam for the winter (December 1 through the end of February) based on Shasta Reservoir EOS storage (the PA component titled Winter-Spring Minimum Flows). These base flows consider historical performance in building Shasta Reservoir cold water pool. Table 2.5.2-4 provides Reclamation's example of possible Keswick releases based on Shasta Reservoir storage condition. Reclamation has indicated that it expects to refine this framework through future modeling efforts as part of seasonal operations planning. NMFS expects this table to reflect initial operations and has therefore analyzed effects according to this assumption. Any subsequent refinement to this schedule would require additional evaluation and potential reinitiation if effects are beyond the range evaluated in this Opinion.

Table 2.5.2-4.	Example of December through Febru	ary Keswick Dam Releas	e Schedule for Various End of
Septe	mber Storages (from Table 4-9 in the	ROC on LTO BA).	

Keswick Release (cfs)	Shasta End of September Storage
3,250	≤ 2.2 MAF
4,000	≤ 2.8 MAF
4,500	≤ 3.2 MAF
5,000	> 3.2 MAF

When considering effects to stressors, winter releases would most likely affect in-river Flow Conditions, Loss of Riparian Habitat and Instream Cover, and contribute to Loss of Natural River Morphology and Function, Loss of Floodplain Habitat, and Water Temperature. There may also be direct effects to redds and rearing fish. Fall-run Chinook salmon redds that are constructed during higher flows along the lateral channel margins can be dewatered as flows are reduced according to proposed operations. Likewise, juveniles rearing at the channel margin can be stranded when flows are lowered. The worst-case scenario for effects to species, in which Keswick Reservoir releases would be 3,250 cfs in December through February, would apply when EOS is less than 2.2 MAF. For the PA, CalSimII modeling indicates that Shasta end of September storage is less than 2.2 MAF in 20 percent of years. This case would result in a reduction in flows from an average September flow of 6,000 cfs below Keswick Dam to a proposed flow of 3,250 cfs in December to conserve/build storage. This is a reduction of nearly 50 percent during a time of year that is typically the start of the precipitation season. Effects of these changes to each species is identified below. Relative to the flows of the COS, CalSimII modeling of the PA shows very small differences in monthly average flow. For the period of December 1 to the end of February, the CalSimII modeling of the PA shows that Keswick releases are generally expected to provide similar or higher flows in the upper reach of the Sacramento River (ROC on LTO BA Appendix D Table 15-3) except in critical water year types, though in discussions during May 20-24, 2019, Reclamation indicated that it intends to operate to the lower flows presented in Table 2.5.2-4.

2.5.2.3.1.1.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

During the period of winter seasonal operations, from December 1 through the end of February, winter-run Chinook salmon fry have emerged from their redds and the majority of juveniles will have migrated past RBDD. Rotary screw trap data (University of Washington Columbia Basin Research 2019) from the last 10 years show that 5 to 10 percent of a brood year's cohort will have yet to migrate past RBDD by December 1 (Figure 2.5.2-11), meaning there is limited potential exposure to the effects of the flow conditions and change in access to riparian habitat due to loss of natural river morphology and function in the spawning area. Flows during the juvenile rearing period (July-December) average about 9,000 cfs downstream of Keswick Dam, which poses a stranding risk to juveniles when flows are reduced. The greatest risk posed by these operations would occur when December flows are reduced to 3,250 cfs. The risk associated with these operations is reflected in the proportion of years that Keswick flows in December would be no greater than 3,250 cfs. Assuming the initial operations reflected in Table 2.5.2-4, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 MAF in about 20 percent of years (ROC on LTO BA Appendix D Table 3-2), and there is therefore a 20 percent probability in any year that December flows would be reduced to 3,250 cfs.

Juvenile stranding generally results from reductions in flow that occur over short periods of time. The analysis uses the monthly flow results provided by CalSimII modeling of PA operations, which is too coarse for a meaningful analysis of the short-term drivers of juvenile stranding. Though all ramping restrictions for dams on the Sacramento River and its tributaries are expected to remain the same for the PA, reservoir releases may vary from year to year in timing of flow fluctuations. There is, therefore, uncertainty to the level of effect of possible stranding on fish. For purposes of the analysis in Section 2.7 Integration and Synthesis of the combined effect of PA implementation when added to the environmental baseline and modeled climate change

impacts, the risk of flow fluctuations in the river reaches below Keswick Dam that can strand winter-run Chinook salmon is assumed to continue. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. For operation of the CVP, this potential stranding has been largely mitigated by maintaining flows above 3,750 cfs and by implementing gradual ramping rates pursuant to Water Rights Order 90-5. NMFS expects that stranding of at least a small proportion of winter-run Chinook salmon juveniles will continue with PA implementation and will adversely affect exposed individuals.

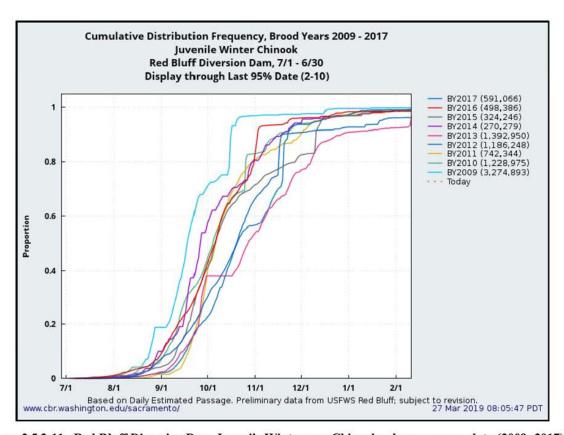


Figure 2.5.2-11. Red Bluff Diversion Dam Juvenile Winter-run Chinook salmon passage data (2009 -2017).

Winter-run Chinook salmon rearing habitat weighted usable area (WUA) analysis in the upper Sacramento River shows that for flows below 12,000 cfs, rearing habitat WUA value peaks at about 4,500 cfs for Reach 5 [Cow Creek to the ACID Dam]. For Reaches 4 (Battle Creek to Cow Creek) and 6 (ACID to Keswick Dam) with the ACID Dam boards in or out, the habitat-flow relationship remains relatively static even with increasing flow (Figure 2.5.2-12). Since the WUA value is "roughly equivalent to the carrying capacity of a stream reach, based on physical conditions" [Bovee (1978) as cited in Payne (2003)], changes in the WUA value describe the effect of flow and flow changes on the carrying capacity of a reach. A relative decrease in WUA could result in either a reduced quality of rearing or could force rearing fry and juveniles to move out of the habitat in to less ideal condition. For either case, a reduced WUA is expected to lead to reduced growth. In the case of this species, the WUA analysis shows the peak habitat carrying

capacity for all upper Sacramento River reaches combined occurs when Keswick releases are approximately 4,500 cfs. This release is within the higher end of the proposed release schedule in **Table 2.5.2-4**; greater habitat reductions as measured by WUA occur at flows less than or greater than 4,500 cfs and are expected to occur when operations require flows to be at those lower levels.

With relation to the stressors Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function, and Loss of Floodplain Habitat, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover in the immediate area of releases but perhaps moreso further downstream (e.g., less frequent inundation of side channels, floodplains, and overtopping of flood system weirs into the Sutter and Yolo bypasses). However, we note that the lower flows proposed in the PA during this time of year would not likely result in changes to riparian habitat, morphology and function, or floodplain habitat in the vicinity of Keswick releases.

With regards to the *Water Temperature* stressor, NMFS notes that reduced winter flows at Keswick Dam can contribute to the ability to increase spring Shasta Reservoir storage levels for the PA relative to recent years. This is expected to increase the available CWP and, therefore, the likelihood of sustaining lower water temperatures during the summer temperature management season.

The exposure, response, and risk to winter-run Chinook salmon to the Winter Minimum Flows component of the PA is summarized in Table 2.5.2-5.

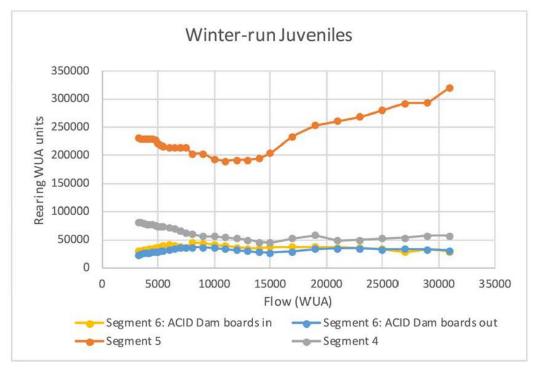


Figure 2.5.2-12. Juvenile winter-run Chinook salmon rearing WUA/flow relationship (Keswick Dam to Battle Creek). Reach 6 is Anderson-Cottonwood Irrigation District (ACID) Dam to Keswick Dam, Reach 5 is Cow Creek to ACID Dam, and Reach 4 is Battle Creek to Cow Creek. Figure and information provided by Reclamation.

2.5.2.3.1.1.2 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

CV spring-run Chinook salmon begin their emigration from the upper Sacramento River in mid-October. By December 1, an average of about 5 to 10 percent of juvenile CV spring-run Chinook salmon are expected to have passed the RBDD rotary screw traps (University of Washington Columbia Basin Research 2019). With the remaining 90 to 95 percent of Sacramento River juvenile CV spring-run Chinook salmon upstream of the RBDD as of December 1, a large proportion of the population would be expected to be exposed to the river conditions that result from the Winter Minimum Flows. Flows during the juvenile rearing period (November - April) average about 8,000 cfs downstream of Keswick Dam, which poses a stranding risk to juveniles when flows are reduced. The greatest risk posed by these operations would occur when December flows are reduced to 3,250 cfs. The risk associated with these operations is reflected in the proportion of years that Keswick flows in December would be no greater than 3,250 cfs. Assuming the initial operations reflected in Table 2.5.2-4, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 MAF in about 20 percent of years (ROC on LTO BA Appendix D Table 3-2), and there is therefore a 20 percent probability in any year that December flows would be reduced to 3.250 cfs. Similar to winter-run Chinook salmon, juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on

fish. For purposes of the analysis in Section 2.7 Integration and Synthesis of the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts, the risk of flow fluctuations in the river reaches below Keswick Dam that can strand CV spring-run Chinook salmon is assumed to continue. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. NMFS expects that stranding of at least a small proportion of CV spring-run Chinook salmon juveniles will continue with PA implementation and will adversely affect exposed individuals.

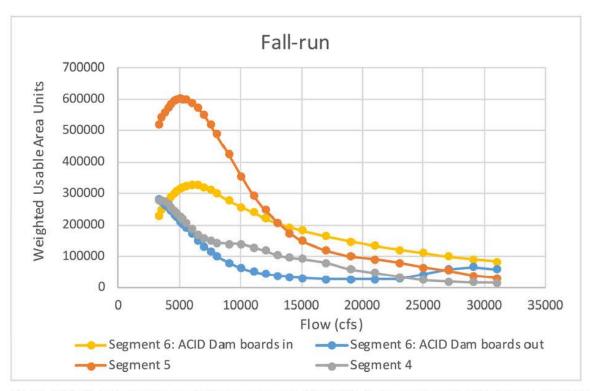


Figure 2.5.2-13. Juvenile fall-run Chinook salmon rearing WUA/Flow relationship (Keswick Dam to Battle Creek). Reach 6 is Anderson-Cottonwood Irrigation District (ACID) Dam to Keswick Dam, Reach 5 is Cow Creek to ACID Dam, and Reach 4 is Battle Creek to Cow Creek. Information provided by Reclamation.

Fall-run Chinook salmon WUA analysis is used as a surrogate for CV spring-run Chinook salmon in the upper Sacramento River (Battle Creek to Keswick Dam) (Figure 2.5.2-13). This analysis shows a decreasing spawning habitat WUA value that corresponds to decreasing flow from 6,000 cfs to 3,250 cfs for segments 5 (Cow Creek to the ACID Dam) and 6 (ACID to Keswick Dam). For segments 4 (Battle Creek to Cow Creek) and for segment 6 with the ACID Dam boards out, the habitat flow relationship peaks at the lowest studied flows (3,250 cfs). Overall, this WUA analysis shows a peak habitat carrying capacity for fall-run, and therefore, CV spring-run Chinook salmon, at flows around 5,000 - 6,000 cfs, which is greater than the range proposed as example initial operations in Table 2.5.2-4. This reduced WUA is expected to lead to reduced growth.

With relation to the stressors Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function, and Loss of Floodplain Habitat, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover in the immediate area of releases but perhaps moreso further downstream (e.g., less frequent overtopping of Fremont Weir). However, we note that the lower flows proposed in the PA during this time of year would not likely result in changes to riparian habitat, morphology and function, or floodplain habitat in the vicinity of Keswick releases.

The exposure, response, and risk to CV spring-run Chinook salmon to the Winter Minimum Flows component of the PA is summarized in Table 2.5.2-5.

2.5.2.3.1.1.3 CCV Steelhead Exposure, Response, and Risk

CCV steelhead express a diverse array of life-history strategies including both anadromous and resident (i.e., rainbow trout) life histories. Anadromous and resident life histories can be adapted by individuals from the same sibling cohort, making determinations regarding run timing difficult. Rotary screw trap data from the last 10 years show that, generally, CCV steelhead begin their emigration from the upper Sacramento River starting in mid-March to early April. During the December-February timing of operations in the Winter Minimum Flows PA component, it is likely that many of the steelhead redds and a large proportion of steelhead juveniles will be exposed to the winter flow conditions and reduced access to riparian habitat. The greatest risk posed by these operations would occur when December flows are reduced to 3,250 cfs. The risk associated with these operations is reflected in the proportion of years that Keswick flows in December would be no greater than 3,250 cfs. Assuming the initial operations reflected in Table 2.5.2-4, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 MAF in about 20 percent of years (ROC on LTO BA Appendix D Table 3-2), and there is therefore a 20 percent probability in any year that December flows would be reduced to 3,250 cfs. The species response to winter flows of 3,250 cfs in the upper Sacramento River would include redd dewatering, stranding, poorer feeding conditions, increased competition and predation related to less floodplain and side-channel habitat and reduced emigration flows.

Similar to winter-run Chinook salmon, juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. For purposes of the analysis in Section 2.7 Integration and Synthesis of the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts, the risk of flow fluctuations in the river reaches below Keswick Dam that can strand steelhead is expected to continue. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. NMFS expects that stranding of at least a small proportion of steelhead juveniles will continue with PA implementation and will adversely affect exposed individuals. With regard to CCV steelhead redds, the USFWS (2006) flow fluctuation and redd dewatering relationship indicates that a flow reduction from 8,000 cfs average flow during the spawning period to 3,250 cfs as prescribed by the end of September Shasta storage level would be expected to dewater approximately 31 percent of steelhead redds. Likewise, flow reductions from 8,000 cfs spawning flows to 4,000, 4,500 and 5,000 cfs would be expected to dewater approximately 22, 17, and 12 percent of redds, respectively. The species response to winter flows of 3,250 cfs in the upper Sacramento River would include dewatering, which could lead to increased egg mortality.

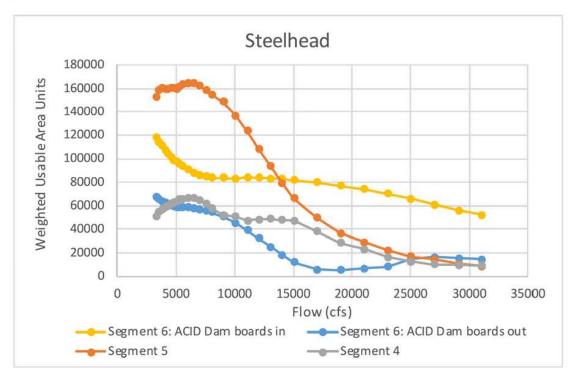


Figure 2.5.2-14. CCV steelhead spawning WUA/Flow relationship (Keswick Dam to Battle Creek). Reach 6 is ACID Dam to Keswick Dam, Reach 5 is Cow Creek to ACID Dam, and Reach 4 is Battle Creek to Cow Creek. Information provided by Reclamation.

Overall, CCV steelhead WUA analysis in the upper Sacramento River (Battle Creek to Keswick Dam) shows a decreasing spawning habitat WUA value that corresponds to flows greater than 3,250 cfs (Figure 2.5.2-14). For segments 5 (Cow Creek to the ACID Dam) and 4 (Battle Creek to Cow Creek), the habitat-flow relationship shows a slight increase in value for flows between 3,250 cfs and 7,000 cfs, with only a slight peak at flows around 6,000 cfs. In this case, the WUA analysis shows an optimum habitat carrying capacity at the lowest modeled flows, around 3,250 cfs.

With relation to the stressors Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function, and Loss of Floodplain Habitat, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover in the immediate area of releases but perhaps moreso further downstream (e.g., less frequent overtopping of Fremont Weir). However, we note that the lower flows proposed in the PA during this time of year would not likely result in changes to riparian habitat, morphology and function, or floodplain habitat in the vicinity of Keswick releases.

The exposure, risk, and response to steelhead to the Winter Minimum Flows component of the PA is summarized with similar information for other species in Table 2.5.2-5.

2.5.2.3.1.1.4 sDPS Green Sturgeon Exposure, Response, and Risk

Because sDPS green sturgeon life history timing is such that spawning occurs from April through July with the median spawning in May (Poytress et al. 2015), it is unlikely that sDPS

green sturgeon will be present in the upper Sacramento River in the December-February period when Reclamation is managing the Winter Minimum Flow component of the PA. However, adult green sturgeon migrate up river in March to early April, and spawning migrations often coincide with high Delta outflow in the spring. Therefore reductions in late winter flows that affect Delta outflow in February and March could impact spawning migration cues. While changes in low flows are unlikely to influence the frequency, magnitude, or duration of the higher flows to which sturgeon respond, we consider that the managed changes in the hydrograph can reduce the strength of the seasonal spawning cues.

Green sturgeon also over-summer in spawning habitats and may be triggered to outmigrate with the first high flows, which sometimes occur in December. Though the extent of this over-summering is not defined, prolonged low winter flows could strand adult green sturgeon in spawning habitat. This was recently observed in the Feather River when green sturgeon outmigrated after spending more than a year in the upper river. While additional water coming into the system below Keswick Dam could reduce potential effects of prolonged minimum flows. this component of operation is expected to result in reduced survival probability in the years in which it occurs.

The exposure, risk, and response to green sturgeon to the Winter Minimum Flows component of the PA is summarized in Table 2.5.2-5.

Table 2.5.2-5. Summary Exposure, Risk, Response table for species and life-stages affected by stressors of the Winter Minimum Flows component of the PA.

Species	Life- stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
Winter- run Chinook salmon	Juvenile s	5% - 10% of population (Medium)	~20% of years	 Water Temperature Flow Conditions Loss of Riparian Habitat and Instream Cover Loss of Natural River Morphology and Function Loss of Floodplain Habitat 	 Decreased growth rate (WUA analyses) Increased survival probability (temperature analyses) Reduced survival probability (dewatering, stranding)
CV Spring- run Chinook salmon	Juvenile s	90 – 95% of population (Large)	~20% of years	 Flow Conditions Loss of Riparian Habitat and Instream Cover Loss of Natural River Morphology and Function Loss of Floodplain Habitat 	Reduced growth rate

Species	Life- stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
Steelhea d	Spawnin g Adults, Redds, Juvenile s	All (Large)	~20% of years	 Spawning Habitat Availability Flow Conditions Loss of Riparian Habitat and Instream Cover Loss of Natural River Morphology and Function Loss of Floodplain Habitat 	 Increased growth rate (WUA analyses) Reduced survival probability (dewatering, stranding)
Green Sturgeo n	Adults	Small	~20% of years	Loss of Natural River Morphology and Function	Reduced survival probability (stranding)

2.5.2.3.2 Shasta Spring Operations

In the spring, the minimum winter reservoir releases (described in Section 2.5.2.3.1.1 Winter Minimum Flows) are maintained until flows are needed to support Sacramento River instream demands and Delta outflow requirements, or releases are required for flood control operations. CVP releases for Delta outflow requirements are coordinated to draw from both Shasta and Folsom reservoirs. Both reservoirs have substantial temperature control requirements, and both need to build substantial storage to be able to fully meet their respective summer temperature compliance requirements. The PA indicates that Reclamation operations intend to balance each reservoir's demands so that the filling of one limits the impact to the other. An overarching objective for Reclamation when operating the CVP is to attain maximum reservoir storage by the end of the flood control season (i.e., the end of May) while still meeting all other authorized project purposes.

NMFS used the modeling provided with the February 5, 2019 BA to evaluate the effects of the PA, though we consider the uncertainties and discrepancies identified in Section 2.5.2.1.2 Project Uncertainties in our analysis.

2.5.2.3.2.1 February Forecast Process and Contractual Water Allocations

For the current operations, Reclamation targets February 20 of each year to make its initial forecast of deliverable water based on an estimate of precipitation and runoff within the Sacramento River basin using the 50 and 90 percent probabilities of exceedance. Reclamation provides this information to water users with an estimate of initial contractual water allocations so that the water users may begin their seasonal planning. Reclamation also provides this forecast to NMFS so that NMFS may determine the likelihood of achieving either a temperature compliance point at Balls Ferry during May - October and/or an EOS storage of at least 2.2 MAF

based on the 90 percent forecast. If neither objective is likely to be met, Reclamation will consult with NMFS monthly on Keswick releases. From March to May, Reclamation submits to NMFS a forecast of monthly average release schedules and proposed temperature compliance point. Based on information provided on May 20, 2019, to NMFS by the Department of the Interior regarding the ROC on LTO PA, NMFS assumes that Reclamation will use a similar conservative forecast for seasonal planning of reservoir releases for the PA (including developing initial and updated allocations) and temperature management planning. This includes monthly release forecasts and associated allocations based on a 90 percent exceedance inflow forecast through September. Reclamation may deviate from relying on the 90 percent exceedance inflow forecast in order to develop a conservative outlook. Such instances include scenarios when a wetter hydrology produces a more conservative outlook, or the actual conditions are significantly drier than the existing forecast such that a more conservative forecast is appropriate. The PA also specifies that when the March 90 percent exceedance runoff forecast and temperature projection indicate a May 1 Shasta storage of less than 2.5 MAF, Reclamation would initiate discussions with NMFS and the USFWS regarding species intervention.

Although not described in detail in the PA, a required element of the February forecast is the initial allocation of deliverable water (primarily delivered in May through October) that includes the north-of-Delta and south-of-Delta allocations (ROC on LTO BA). As described in Section 2.5.2.1 Shasta Annual Operations, releases made from Shasta and Keswick dams to contribute to meeting these allocations have an effect on Reclamation's ability to build or maintain storage, which in turn affects Reclamation's ability to provide adequate temperatures for spawning fish and incubating eggs during the summer. CalSimII modeling of both the COS and the PA show relatively similar delivery amounts for the north-of-Delta deliveries for the two scenarios (see Table 2.5.2-6 and Table 2.5.2-7). However, based on the PA modeling results, Reclamation does not show frequent instances of curtailing water service allocations to achieve a higher storage on May 1. While Section 2.5.2.3.3 Shasta Summer Operations describes the modeled likelihood of Reclamation operating to a particular "Tier" of summer cold water pool management, unforeseen events (e.g., reduced solar radiation from cloud or smoke cover, unusual Delta salinity conditions) can require a change of Tier within a year. In the absence of commitment in the PA to build storage to a particular storage metric during the spring, NMFS relies on the modeled characterization of May 1 storage and temperature management conditions. To address the uncertainty related to species' exposure to temperature conditions, we have used the modeling results of the PA as a boundary characterization of the frequency of exposure to temperatures in the summer. Moreover, because the PA includes full implementation and performance of northof-Delta settlement contracts and is seeking take authorization for those contracts, this Opinion analyzes the effects of Reclamation's operations to meet those contract requirements on the likelihood of attaining temperature metrics.

We note that the deliveries for north-of-Delta contracts commonly begin in April, the start of the spring operations period, and that deliveries are of small magnitude during this month. Before reaching the highest demands in summer months, combined deliveries average more than 300 TAF in May, even in drier water year types (Table 2.5.2-6 and Table 2.5.2-7). Reclamation uses a rule of thumb relationship between storage on May 1st and achievable seasonal temperatures along with modeling based on expected available coldwater pool to select a tier. An assumption of historical deliveries is incorporated into the rule of thumb relationship and a conservative estimate of deliveries will be incorporated in the temperature modeling. For this reason,

Reclamation does not expect a change in tiers between May 1st and May 15th (the start of temperature management) due to expected water deliveries nor does Reclamation expect a change in tiers throughout the season due to forecasted deliveries. Because these demands are estimated when tiers are selected, the effects of these releases are assumed to be covered in the analysis of the PA and Reclamation would not anticipate a reduction in the performance of the PA due to months of high deliveries. The combined modeled north-of-Delta deliveries in April, May, and June even in dry years average over 800 TAF (see rows corresponding to "D" under "AVG BY WYT" in Table 2.5.2-6 and Table 2.5.2-7). NMFS notes that the recent experience of the extreme drought in 2014 through 2016 and associated modelling scenarios demonstrates that the volume and stability of cold water throughout the temperature management season can be adversely affected by June and early July deliveries in addition to deliveries in April and May.

Table 2.5.2-6. Average north-of-Delta water service agricultural service contract deliveries by month and water-year type for both the COS¹⁰ and PA.

						<=====	Allocation/	Contract	Year					Full Year	
	20 M M M M M M			PR 101 101 101 101 101	*****								Oct-Apr	Mar-Feb	Allocation
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT	TOT	PCT
AVG:	4.7	0.2	0.0	0.0	0.1	1.2	18.5	36.9	47.6	56.9	45.4	20.2	24.6	230.3	65%
MIN:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0%
MAX:	14.9	1.9	0.0	0.0	4.4	17.2	44.3	63.8	81.5	95.8	77.5	37.5	65.5	357.1	100%
Avg by WYT	PRV	PRV	PRV												
W:	6.9	0.3	0.0	0.0	0.0	0.8	21.5	50.2	68.0	81.4	65.4	30.0	27.0	324.7	91%
AN:	5.2	0.1	0.0	0.0	0.0	0.5	23.7	50.0	65.3	77.3	61.1	27.5	28.1	308.4	86%
BN:	4.5	0.4	0.0	0.0	0.5	3.2	22.8	38.4	43.1	52.7	41.8	16.8	32.3	223.7	63%
D:	3.0	0.0	0.0	0.0	0.2	0.9	13.2	24.9	30.6	35.9	28.7	12.2	20.3	149.4	42%
C:	2.1	0.1	0.0	0.0	0.0	1.5	11.1	12.8	17.0	20.3	16.3	7.5	15.6	88.6	25%
				PJ	: North-c	f-Delta D	eliveries to	CVP Ag	Service Co	ntractors	in TAF				
						<======	Allocation/	Contract	Year			*****		Full Year	
	*****	*****		****	****>								Oct-Apr		Allocation
	OCT	NOA	DEC		FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT	TOT	PCT
AVG:	5.2						200	40.6	52.5	62.7	50.1	22.1	27.7	254.8	
	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.9	1.2	1.4	1.1	0.5	0.6		
MIN:												37.5	77 7	357.1	100%
MIN: MAX:	14.9	1.9	0.0	0.0	4.4	19.9	51.5	63.8	81.5	95.1	75.8	37.5	72.7	337.1	
		1.9 PRV	0.0 PRV		4.4	19.9	51.5	63.8	81.5	95.1	/5.8	37.3	12.1	357.1	
MAX:	14.9	PRV	PRV					63.8 51.0	70.0	95.1	67.1	30.8	28.5		93%
MAX: Avg by WYT	14.9 PRV	PRV 0.3	PRV 0.0	0.0	0.0	0.8	22.6							333.8	93% 92%
MAX: Avg by WYT W:	14.9 PRV 7.2 5.5 5.7	PRV 0.3 0.1 0.5	PRV 0.0 0.0	0.0	0.0 0.0 0.5	0.8 0.6 4.3	22.6 25.5	51.0	70.0	83.7	67.1	30.8	28.5	333.8 328.3	92% 80%
MAX: Avg by WYT W: AN:	14.9 PRV 7.2 5.5	PRV 0.3 0.1 0.5	PRV 0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.5	0.8 0.6 4.3	22.6 25.5 28.8	51.0 51.2	70.0 69.7	83.7 82.2	67.1 65.1	30.8 29.2 21.1	28.5 30.2	333.8 328.3 285.8	92% 80%

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¹⁰ NMFS notes that the COS modeling does not reduce deliveries to agricultural service contractors, an action that is an option in annual operations.

Table 2.5.2-7. Average north-of-Delta settlement contract deliveries by month and water-year type for both the COS¹¹ and PA.

						<=====	Allocation	Contract	Year					Full Year	Fraction of
	****				>								Oct-Apr	Mar-Feb	Hist Max
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOT	TOT	PCT
AVG:	75.7	24.0	7.3	1.4	0.6	7.1	81.0	305.9	352.0	381.6	294.3	77.1	197.1	1608.7	94%
MIN:	6.2	3.5	0.0	0.0	0.0	0.0	29.1	145.5	287.4	322.0	241.0	23.5	60.2	1388.2	81%
MAX:	95.9	43.7	20.1	9.0	13.6	58.6	123.7	358.8	398.9	407.7	331.1	89.7	302.1	1719.1	100%
Avg by W	PRV	PRV	PRV												
W:	78.5	24.1	8.8	0.8	0.0	3.1	70.0	301.7	335.8	392.3	318.6	81.3	170.6	1617.0	94%
AN:	75.4	23.7	6.2	0.5	0.0	1.6	78.0	300.2	350.0	388.8	298.8	79.0	179.8	1607.9	94%
BN:	75.3	26.6	7.4	2.9	1.9	13.3	90.3	314.4	364.6	390.3	293.4	69.8	219.5	1646.4	96%
D:	76.9	20.8	7.6	1.7	0.9	7.3	83.2	320.3	378.9	384.4	282.8	76.8	208.6	1640.5	95%
C:	68.3	27.3	4.5	1.8	0.9	15.3	95.5	289.8	332.8	338.4	256.6	72.9	233.4	1504.2	88%
					PA: Nort	h-of-Delta	Deliveries	to CVP S	Settlement	Contra	ctors in	TAF			
						<====	Allocation	Contract	Year		***	No. 40 No. 40 No. 40		Full Year	Fraction of
				W 40 10 10 10 10 10 10 10 10 10 10 10 10 10	===>	< 10 to 10 to 10	Allocation	/Contract	Year		****	NOT THE THE THE THE	Oct-Apr	Full Year Mar-Feb	Fraction of Hist Max
	OCT	NOV	DEC	JAN	===> FEB	<==== MAR	Allocation	/Contract	Year	JUL	AUG	SEP			
AVG:			DEC	JAN		MAR				JUL. 382			Oct-Apr	Mar-Feb	Hist Max
AVG: MIN:	OCT	NOV	7 0	JAN 1 0	FEB	MAR 7	APR 81	MAY	JUN		AUG	SEP 77	Oct-Apr TOT	Mar-Feb TOT 1599	Hist Max PCT
	ост 60	NOV 30	7 0	JAN 1 0	FEB	MAR 7 0	APR 81 29	MAY 306	JUN 352	382	aug 294	SEP 77 24	Oct-Apr TOT 187	Mar-Feb TOT 1599	Hist Max PCT 93%
MIN:	60 6 6 86	NOV 30 12	7 0	JAN 1 0	FEB 1	MAR 7 0	APR 81 29	MAY 306 146	JUN 352 287	382 322	AUG 294 238	SEP 77 24	Oct-Apr TOT 187 66	Mar-Feb TOT 1599 1372	Hist Max PCT 93% 80%
MIN: MAX:	60 6 6 86	30 12 49	7 0 20 PRV	JAN 1 0 9	FEB 1	MAR 7 0 59	APR 81 29 124	MAY 306 146	JUN 352 287	382 322	AUG 294 238	77 24 90	Oct-Apr TOT 187 66	Mar-Feb TOT 1599 1372 1715	Hist Max PCT 93% 80%
MIN: MAX: Avg by WY W:	60 6 86 PRV	30 12 49 PRV	7 0 20 PRV 9	JAN 1 0 9 1	1 0 14	MAR 7 0 59	APR 81 29 124	MAY 306 146 359	352 287 399	382 322 408	294 238 335	77 24 90	Oct-Apr TOT 187 66 295	Mar-Feb TOT 1599 1372 1715	PCT 93% 80% 100%
MIN: MAX: Avg by WY W: AN:	60 6 86 PRV 62	9 PRV 30	7 0 20 PRV 9 6	JAN 1 0 9 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 14	MAR 7 0 59 3 2	APR 81 29 124 70 78	MAY 306 146 359	352 287 399	382 322 408 392	AUG 294 238 335	SEP 77 24 90 81 79	Oct-Apr TOT 187 66 295	Mar-Feb TOT 1599 1372 1715	PCT 93% 80% 100% 94%
MIN: MAX: Avg by W	60 6 86 86 PRV 62 60	9 PRV 30 29	7 0 20 PRV 9 6	JAN 1 0 9 1 1 0 0 3	0 0 0 0 0 0	MAR 7 0 59 3 2	70 78 90	306 146 359 302 300	352 287 399 336 350	382 322 408 392 389	294 238 335 319 299	SEP 77 24 90 81 79	Oct-Apr TOT 187 66 295	Mar-Feb TOT 1599 1372 1715 1607 1597	93% PCT 93% 80% 100% 94% 93%

Reclamation has stated that springtime operations of Shasta and Keswick dams are intended to support instream demands on the mainstem Sacramento River and Delta outflow requirements. In February and March 2019 conversations with NMFS, Reclamation formally stated that they agree with the interpretation of the PA that contract supply quantities will not be reduced to build storage or meet temperatures in a specific summertime operational Tier. NMFS also considers that Reclamation lacks legal ability to deliver less than the base contract amounts to the Sacramento River Settlement Contractors, and notes that the extreme drought in 2014 through 2016 and associated modelling scenarios demonstrated that the volume and stability of cold water throughout the temperature management season can be adversely affected not only by April and May deliveries but also by deliveries in June and early July. The combined modeled north-of-Delta deliveries for the PA in April, May, and June in dry eyars can average over 800 TAF (see rows corresponding to "D" under "AVG BY WYT" in Table 2.5.2-6 and Table 2.5.2-7) and NMFS considers that the modeling does not capture any modifications to the timing of these deliveries to futher assist temperature management. During Shasta Critical Years, as defined under the Sacramento River Settlement Contracts, those contract quantities are reduced to 75 percent. However, the CalSimII results are the best available information for evaluating effects of spring operations for the PA and COS. NMFS has considered historical operations regarding these contracts but does not have adequate information to quantitatively or qualitatively include deviations from the modeled operations into the assessment of effects. NMFS therefore assumes that the CalSimII model results of flows below Keswick Dam in

¹¹ NMFS notes that the COS modeling does not reduce deliveries to agricultural service contractors, an action that is an option in annual operations.

February through May provide a reasonable approximation of the effects of operational decisions, including fulfilling underlying contractual obligations, that are being made regarding spring operations for both the COS and the PA. Table 2.5.2-6 and Table 2.5.2-7 capture modeled volumes of storage draw down to meet contracts which can be considered when assessing impacts of deliveries on summertime temperature management actions. This modeling shows that from February through May, the PA is very similar to COS with PA flows below Keswick Dam a few hundred cfs higher than the COS (Table 2.5.2-8). Though it is limited in that it cannot capture all conditions or constraints on operations, the CalSimII modeling shows that in the spring, the PA would increase north-of-Delta agricultural service contract deliveries (Table 2.5.2-6), decrease Delta outflow (Table 2.5.2-9), and increase total exports (Table 2.5.2-10) compared to the COS.

Table 2.5.2-8. CalSimII modeling results of flows below Keswick, PA minus COS (excerpted from ROC on LTO BA, Table 15-3 of Appendix D).

Proposed	Action 011519 minus	Current O	perations 011319
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						Monthly Fie	ow (CFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	-62	-3,506	2,881	3,372	149	598	307	634	1,100	0	-87	-6,327
20%	211	-3.836	2,738	2,626	-2,183	402	187	790	1,374	0	50	-5,603
30%	489	-2,657	1,564	1,963	1,009	554	882	933	1,340	-128	94	-5,332
40%	-33	-2,313	411	2,020	1,345	2,124	0	625	771	-347	276	-3,597
50%	-112	-1,297	500	0	750	0	0	649	966	-122	135	-953
60%	58	-1,311	299	0	0	0	0	526	489	-99	75	-430
70%	1	-272	0	0	0	0	0	359	102	-222	99	-355
80%	-25	40	0	0	0	0	0	523	48	-30	139	-176
90%	-186	0	0	0	0	0	0	489	1	-12	135	22
Long Term Full Simulation Period ^a	-35	-1,545	946	782	360	408	97	530	643	-93	120	-2,501
Water Year Types b,o												
Wet (32%)	-193	-3,522	2,065	1,108	170	85	114	249	106	-89	173	-5,746
Above Normal (16%)	1	-3,065	1,218	1,366	1,179	686	26	484	379	66	9	4,706
Below Normal (13%)	-75	1	19	1,396	1,014	869	439	977	1,327	188	183	515
Dry (24%)	151	102	370	125	1	383	22	856	1,073	-133	193	-64
Critical (15%)	-6	222	38	-24	-120	424	-54	236	746	-466	-56	92

a Based on the 82-year simulation period.

b As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).

c These results are displayed with calendar year - year type sorting.

d All scenerios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

e These are dreft results meant for qualitative analysis and are subject to revision.

Table 2.5.2-9. CalSimII modeling results of Delta outflow, PA minus COS (excerpted from ROC on LTO BA, Table 41-3 of Appendix D).

Proposed	Action 01	1519 minus	Current (Operations	011310

					N.	Ionthly Out	flow (CFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	-2,320	2,128	2,932	1,887	1,439	4,592	-5,178	-5,280	536	-698	91	-14,058
20%	-4,996	-6,009	2,669	2,638	957	437	-4,528	-3,315	727	-532	-12	-15,148
30%	-5,223	-7,836	4,505	-245	-506	-1,149	-3,824	-3,400	641	66	0	-11,288
40%	-2,969	-7,267	986	53	3,753	-1,206	-3,976	-4,003	741	0	0	-6,941
50%	-1,374	-5,199	755	1,412	217	-558	4,361	-2,698	516	0	0	142
60%	0	-1,811	1,097	-293	-499	1,102	-2,854	-1,487	238	0	0	0
70%	0	0	560	201	-815	-902	-2,482	-719	163	0	-173	0
80%	0	0	406	-119	-1,150	-232	-1,492	-263	1,056	0	-211	0
90%	0	0	0	-146	-502	-1,493	-587	-234	326	0	0	0
Long Term Full Simulation Period ²	-1,574	-2,522	2,133	709	466	450	-2,949	-2,367	479	-147	-44	-5,300
Water Year Types b,o												
Wet (32%)	-3.584	-5,943	4,477	1,771	1,256	1,009	-4,446	-4,039	751	-266	1	-13,297
Above Normal (16%)	-1,982	-3,628	3,075	673	2,046	2,175	4,167	-3,157	840	-506	-10	-7,069
Below Normal (13%)	-312	-467	516	739	2,357	508	-2,597	-1,810	343	26	55	167
Dry (24%)	-335	30	644	-93	-1,392	-680	-1,777	-1,120	264	56	-181	57
Critical (15%)	0	-48	0	-241	-1,596	-799	-663	-476	-16	0	-40	0

a Based on the 82-year simulation period.

Table 2.5.2-10. CalSimII modeling results of total exports, PA minus COS (excerpted from ROC on LTO BA, Table 53-3 of Appendix D).

Proposed Action 011519 minus Curre	nt Operations 011319
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	Monthly Delivery (CFS)											
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	3,461	32	-35	-126	-140	-449	4,529	4,571	-521	11	0	0
20%	3,638	1,945	-758	46	-78	-565	4,815	4,974	-90	0	0	10
30%	3,215	2,081	-1,670	533	15	-359	4,497	4,235	-364	144	-20	.0
40%	2,330	1,575	-773	312	213	53	4,438	4,086	-324	93	0	130
50%	1,299	1,172	-700	398	402	211	3,838	3,693	747	-506	543	1,019
60%	361	491	-696	308	373	318	3,062	2,836	1,296	-415	926	747
70%	182	-170	-700	380	729	1,145	1,707	2,211	1,401	-783	120	-136
80%	27	-231	-47	680	1,703	1,225	1,304	1,734	2,304	-1,462	151	-173
90%	-174	-21	-118	1,381	2,951	2,198	954	877	1,441	-665	32	-105
Long Term Full Simulation Period ²	1,397	726	-548	393	742	404	2,971	2,977	660	-272	149	215
Water Year Types b,o												
Wet (32%)	2,688	2,341	474	312	-31	-502	4,476	4,244	-232	-24	-79	304
Above Normal (16%)	2,645	258	-1,579	899	149	-225	4,433	3,966	-152	400	-58	144
Below Normal (13%)	99	52	-615	737	1,071	548	2,737	2,865	1,656	226	1,099	518
Dry (24%)	445	-281	-157	148	1,371	1,234	1,549	2,069	1,544	-1,161	252	69
Critical (15%)	24	34	-183	110	1,709	1,535	713	781	1,089	-512	-178	64

a Based on the 82-year simulation period.

b As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).

c These results are displayed with calendar year - year type sorting.

d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

e These are draft results meant for qualitative analysis and are subject to revision.

b As defined by the Secrements Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 0-1641, 1999).

c These results are displayed with calendar year - year type sorting.

d All scenarios are simulated at ELT (Early Long-Term) OS with 2025 climate change and 15 cm sea level rise. e These are dreft results meant for qualifative analysis and are subject to revision.

The RPA of the NMFS 2009 Opinion requires Reclamation to consider a number of actions in drought (or low Shasta storage conditions) to help conserve and/or build Shasta storage for better cold water pool management. One of these actions requires Reclamation and DWR to make releases first from Folsom Reservoir and then from Oroville Reservoir to meet Delta outflow or other legal requirements before making releases from Shasta Reservoir. Although this only occurred once during the extreme drought in 2014-2016, such an action would increase the ability to conserve storage in Shasta Reservoir to the maximum extent practicable. The 2018 revision to the COA reduced the sharing commitments between Reclamation and DWR from the CVP reservoirs, including Shasta, in dry and critical years as compared to historical operations. In meetings during May 2019, Reclamation confirmed verbally that further preferential drawing from Oroville Reservoir on a regular basis beyond that outlined in the 2018 COA would be unlikely, although such an action (along with other actions) may be considered in extreme dry periods under a drought contingency plan. Reclamation has committed to coordinating with DWR to develop a voluntary toolkit to be exercised at the discretion of Reclamation, DWR, other agencies, participating water users, and/or others for the operation of Shasta Reservoir during critical hydrologic year types. Reclamation will meet and confer with USFWS, NMFS, DWR, CDFW, and Sacramento River Settlement Contractors on voluntary measures to be considered. In addition, the Sacramento River Settlement Contractors commit to meet and confer with Reclamation and NMFS to determine if there is any role for the Sacramento River Settlement Contractors in connection with Reclamation's operational decision-making for Shasta Reservoir in Tier 3 and Tier 4 years. Implementation of a drought contingency plan will be based on the real time conditions observed and the interaction with other State and Federal requirements.

2.5.2.3.2.2 Spring Base Flows

As the pre-dam hydrograph in Figure 2.5.2-2 shows, the median monthly flows for February through April would naturally have been at nearly double the flowrate currently managed to flow into the upper Sacramento in more recent decades. Reclamation is proposing to maintain the minimum winter releases (described in Section 2.5.2.3.1.1 Winter Minimum Flows) into the spring and until "flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements" (U.S. Bureau of Reclamation 2019). Modeling confirms that for both the PA and the COS, early spring (February - April) flows are maintained at minimum levels to build storage. The CalSimII modeling indicates that Sacramento River flows at Keswick Dam are increased in the late spring (May), but because Delta outflow remains constant, this increase in Keswick release is done to meet agricultural demands and south-of-Delta exports rather than to meet Delta outflow requirements. Regardless of the driver of the May increase, keeping flows at Keswick Dam artificially low restricts the river's "natural" physical, biochemical, and ecosystem functions (Yarnell et al. 2015, Mount et al. 2017).

In the Sacramento River, the dynamic natural flows that would result from unregulated tributary contributions have been replaced by a spring base flow – a single minimum instream flow intended to be sufficient to maintain aquatic species during crucial low-flow periods. This is in contrast to the tributaries of the upper Sacramento River, which mostly have unmodified hydrographs subject to a seasonal flow regime. This contrast, between the unmodified flows of the tributaries and the minimum flows in the mainstem, creates a hydrologic disconnect for juveniles migrating out of the tributaries. Juvenile CV spring-run Chinook salmon migration out

of Mill and Deer creeks begins in mid-to-late April, extends through May, and is triggered by spring storm events or warming air temperatures causing rapid snowmelt. Peak migration out of these tributaries typically occurs early to mid-May according to 15 years of rotary screw trap data (1995-2010). And while CalSimII modeling of the PA and COS shows Keswick releases increasing in May for the PA, this increase is made in part to satisfy agricultural deliveries which then reduce flows downstream of the point of diversion (i.e., at Wilkins Slough). These diminishing flows are also described in the modeling for both the PA and the COS where average flows at Wilkins Slough in May are approximately 6,500-7,000 cfs, which is 1,200-1,300 cfs lower than flows below Keswick Dam. For those fish originating from Battle, Cottonwood, and Clear creeks, as well as from the mainstem Sacramento River, juvenile migration past RBDD occurs November to May (University of Washington Columbia Basin Research 2019). These fish are therefore subject to the drastically reduced managed spring flow hydrograph and the resulting low flow habitat conditions created by the spring base flows; a managed spring pulse flow could alleviate effects of these low flow habitat conditions. A similar effect could manifest for adult sDPS green sturgeon that migrate up river in March to early April coincident with high Delta outflow. We consider that the managed changes in the hydrograph can reduce the strength of the seasonal spawning cues for this species, and a managed spring pulse flow could alleviate the effects of the managed low flows.

The PA states that spring releases (besides flood control operations) are expected to be steady until flows are needed to support instream demands on the mainstem Sacramento River and Delta outflow requirements. In wetter springtime conditions, downstream demands are generally met through unstored accretions to the system, and Reclamation expects to be able to reduce Keswick flows below those proposed for the fall-winter period.

Salmon and sturgeon have access to floodplain habitat such as the Yolo and Sutter bypasses in springtime during higher flow events, and the quantity of floodplain available for rearing during drought years is currently limited. The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile salmon over a longer period (California Department of Water Resources and U.S. Bureau of Reclamation 2012). This project, which was included as RPA Action I.6.1 of the NMFS 2009 Opinion, is considered in the environmental baseline of this Opinion because section 7 ESA consultation was completed on May 10, 2019. However, the project is not yet completed, and Reclamation clarified in a meeting with NMFS on June 25, 2019, that there is no commitment to implement the project beyond current year appropriations. Still, the action is not included in the PA of the 2019 ROC on LTO BA (ROC on LTO BA Table 4-6) because doing so would preclude it from eligibility for various future funding opportunities.

The springtime flows advanced in the PA can contribute to the *Loss of Floodplain Habitat* stressor. The flow reductions in March through May, which artificially detain high natural flows, can be expected to limit access to food-rich floodplain habitat and reduce juvenile salmonid survival during rearing and downstream migration. A recent assessment of mark-recapture survival models in the Sacramento mainstem show that flow correlates with out-migration success (Iglesias et al. 2017), providing additional evidence that flow is one of the most important factors affecting overall survival of Chinook salmon in the Central Valley (Kjelson and Brandes 1989, Zeug et al. 2014, Michel et al. 2015). Analysis of recent tagging data for both CV spring-run Chinook salmon and fall-run Chinook salmon show faster migration times and higher survival correlated to the the year with higher flow conditions (Cordoleani et al. 2018).

Therefore, while reducing reservoir releases helps build storage for the following temperature management season, doing so also has a negative effect floodplain access and therefore on downstream migration and survival.

2.5.2.3.2.3 Spring Pulse Flows

Reclamation is proposing to implement a spring pulse flow under certain hydrologic conditions to improve the survival of out-migrating juvenile salmonids, specifically CV spring-run Chinook salmon. In coordination with the NMFS-SWFSC, NMFS has recently developed a CV spring-run Chinook salmon pulse flow experiment to assess the effectiveness of a spring pulse flow that is implemented through coordinated water operations (i.e., either increased reservoir releases or decreased river diversions). Existing data from previous telemetry studies (Michel et al. 2015, Notch 2017) show that increases in survival in the upper and lower Sacramento River have been strongly correlated with increases in flow resulting from tributary accretions. These increases in flow during past telemetry studies were triggered by storm events resulting in increased outflow from Sacramento River tributaries. CV spring-run Chinook salmon and fall-run Chinook salmon tagging data from 2012-2017 show a significant increase in smolt survival when Sacramento River flow at Wilkins Slough is above 9,100 cfs during the outmigration period (Cordoleani 2019). Although it remains to be seen whether a spring pulse flow mediated by water operations would have the same benefit as a natural rain-driven spring pulse, Reclamation is proposing a spring pulse flow as part of water operations with consideration of certain hydrologic and operational constraints.

Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether to make a spring pulse of up to 150 TAF in coordination with the Upper Sacramento scheduling team. To support their ability to improve temperature conditions, Reclamation would not make a spring pulse release if the release would cause operations to drop into a warmer Tier of the Shasta summer cold water pool management tiers (e.g., the additional flow releases would decrease cold water pool such that summer Shasta temperature management operations move to Tier 3 from an initial operation of Tier 2) or interfere with the ability to meet other anticipated demands on the reservoir

For the operations described in the PA, Reclamation, in coordination with the Upper Sacramento scheduling team, could implement up to 150 TAF of spring pulse flows for juvenile salmonid outmigration if Shasta Reservoir total storage on May 1 is projected to be sufficient for cold water pool management (i.e., greater than 4 MAF). Reclamation would evaluate the projected May 1 Shasta Reservoir storage at the time of the February forecast to determine whether a spring pulse would be allowed in March, and would evaluate the projected May 1 Shasta Reservoir storage at the time of the March forecast to determine whether a spring pulse would be allowed in April. Though not explicitly specified in the BA, NMFS assumes that this projection will be based on the 90 percent exceedance forecast in March and April. CalSimII modeling results indicate that Shasta Reservoir May 1 storage is greater than 4 MAF in about 75 percent of years. However, these results include the model's perfect foresight of conditions. Given the uncertainty of actual forecasting, it is likely that May 1 Shasta Reservoir storage of 4 MAF would occur less frequently. NMFS is therefore uncertain in the frequency of the implementation of a spring pulse flow and assumes that it would occur in fewer than 75 percent of years.

Implementing a spring pulse to benefit out-migrating juveniles can affect temperature-dependent egg mortality in the summer by reducing the volume of water available for use later in the season. Even though the pulse may occur in May, the impacts to temperature management might not manifest until the end of the season when the volume of cold water is likely at its lowest. Recent analysis of the effects of a 10,000 cfs spring pulse at Wilkins Slough focused on estimating the spring pulse impact on winter-run Chinook salmon temperature-dependent egg mortality and the water cost associated with conducting a spring pulse originating from Shasta Reservoir (Daniels et al. 2019). The ensemble-based approach simulated the spring pulse over a 16-year period (2000-2015), assuming this represented a reasonable range of meteorology, hydrology, and operations for the near future. For each day from May 1 to May 15 during the pulse time window for a given simulation year, the analysis estimated the volume of water required for Wilkins Slough discharge to equal 10,000 cfs for three continuous days, followed by a 15 percent daily ramping down rate to base conditions. This volume of water represented the additional amount of water required from Shasta Reservoir for the pulse to occur. Since the calculation was run for each day in the pulse time window, it was possible to assess the sensitivity of the water cost associated with the day the pulse started and estimated a range of potential water cost values.

Using this information, a "pulse" and a "no pulse" scenario were evaluated using the temperature-dependent egg mortality model for each simulation year. The no pulse model used observed conditions for all model inputs and was considered the base model. The pulse model used observed conditions, except for discharge from Shasta and Keswick reservoirs, and in the Sacramento River during the time period when a pulse was considered. During that time period the time series was perturbed to simulate a pulse.

This analysis found that the simulated effect of the spring pulse varied by water year type, with the largest impact occurring during dry and critical years. Water costs associated with a spring pulse varied from zero TAF during wet years to as much as 50 TAF during drier hydrological years. In most years, the water cost was less than 30 TAF (Figure 2.5.2-15). The releases of water in the spring period had effects on temperature management later in the summer season; the simulated increase in Shasta discharge temperature associated with the spring pulse was often less than 0.5°F, but was as much as 1°F. The effects of the simulated May pulse operation on temperature management later in the year results in a simulated winter-run Chinook salmon temperature-dependent egg mortality increase that was often less than 2 percent, mostly in below normal, above normal, and wet water year types (Figure 2.5,2-16). Dry and critically dry years had an average increase of more than 4 percent in winter-run Chinook salmon egg mortality, but the range was as high as 8 percent when considering the 75th percentile estimate. This analysis considered survival over the entire time period from the pulse to the end of December for a given year. These results support Reclamation's proposal to implement this action in wetter water years, and when Shasta Reservoir total storage on May 1 is projected to be sufficient for cold water pool management.

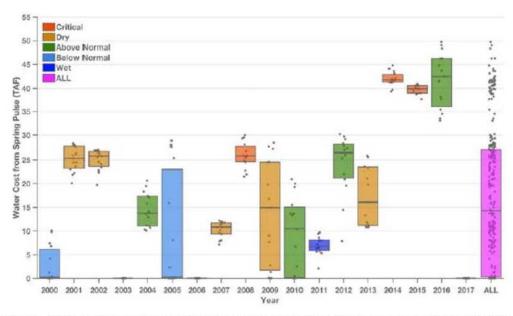


Figure 2.5.2-15. Water costs associated with spring pulse simulation. Box encompasses 25th and 75th percentile of water cost associated with sensitivity to pulse start date. Preliminary data figures from Daniels et al. (2019).

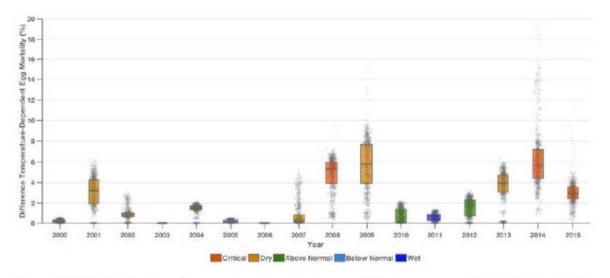


Figure 2.5.2-16. Distribution of temperature-dependent egg mortality increase associated with simulated pulse. Boxes encompass 25th and 75th percentile associated parameter uncertainty from 50 ensembles. Preliminary data figures from Daniels et al. (2019).

As proposed, a spring pulse flow occurring between March 1 and May 15 is expected to result in increased survival of juvenile salmonids by mimicking the natural hydrologic cues that trigger salmonid outmigration (Kjelson et al. 1981). Although a managed spring pulse is expected to increase juvenile survival during outmigration, NMFS assumes some of the benefits of a natural

rain-driven spring pulse would likely not occur. For example, a natural rain-driven spring pulse would likely result in increased turbidity, which would provide a level of cover for outmigrating juveniles that may not occur with a managed spring pulse, increasing juvenile protection from predators.

2.5.2.3.2.3.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

The proposed spring pulse flows would occur sometime from March 1 to May 15 when the majority of winter-run Chinook salmon juveniles either have entered the Delta or have completed their migration to the ocean. Rotary screw trap data over the last 10 years from Knights Landing, located just upstream of the Delta, show that by early to mid-February, 95 percent of winter-run Chinook salmon juveniles have entered the Delta (Figure 2.5.2-17) and migrated downstream past the influence of a spring pulse flow. For winter-run Chinook salmon juveniles, exposure to the spring pulse is small, occurring in fewer than 75 percent of years, and in those years, less than 5 percent of the year-class is expected to be influenced. We expect increased survival for those juveniles exposed to the spring pulse as a result of decreased travel time and decreased predation risk.

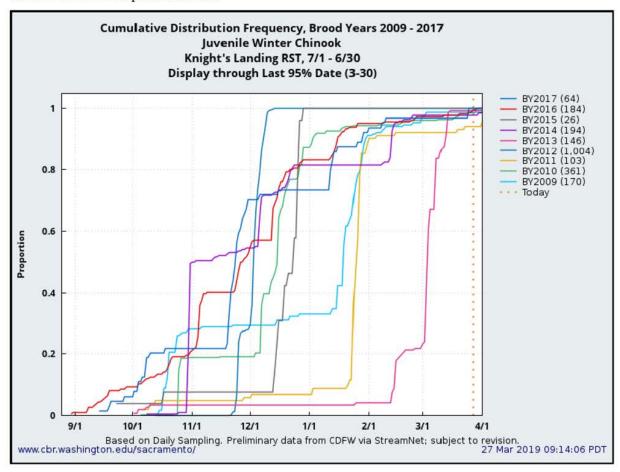


Figure 2.5.2-17. Knights Landing RST Juvenile Winter-run Chinook passage data from 2009-2017.

Spring pulses are also expected to benefit adult winter-run Chinook salmon migrating up the Sacramento River later in the spring. The spring pulses would provide improved *Flow Conditions* that in turn provide cooler temperatures (improved *Water Temperature*), and allow for better passage conditions.

However, as the analysis of Daniels et al. (2019) shows, a springtime pulse could have an effect on the ability to manage cold water throughout the summer temperature management season. This could increase the risk of temperature-dependent mortality to winter-run Chinook salmon eggs later in the year (e.g., September and October) when the cold water pool is smaller and, therefore, more constrained in its use for river temperature management. The pulse is assumed to occur in fewer than 75 percent of years, and in mostly wetter years when May 1 storage is greater than 4 MAF. The analysis showed that risk to winter-run Chinook salmon in these years was often a less than 2 percent increase in temperature-dependent mortality, though the increase was greater in drier water year types, sometimes increasing up to over 7 percent.

With relation to the stressors Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function, and Loss of Floodplain Habitat, NMFS considers that the managed changes in the hydrograph can alter access to riparian habitat and instream cover in the immediate area of releases but perhaps moreso further downstream (e.g., altered frequency of inundation of side channels, floodplains, and overtopping of flood system weirs into the Sutter and Yolo bypasses). The flows provided by a spring pulse can lessen the effects of these stressors, but we note that the frequency of pulses may limit the reduction of these stressors.

The exposure, risk, and response of winter-run Chinook salmon to the Spring Pulse Flows component of the PA is summarized in Table 2.5.2-11.

2.5.2.3.2.3.2 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

The proposed spring pulse flow is intended to coincide with the migration timing of juvenile CV spring-run Chinook salmon. Juvenile CV spring-run Chinook salmon migration into the Delta begins in winter and continues through early May, ending just before the end of the spring pulse flow period (May 15). Specifically, based on the last 10 years of Knights Landing RST data, March 1 corresponds to a median date of CV spring-run Chinook salmon passage at Knights Landing of about 25 percent. Therefore, depending on when a pulse flow is implemented, up to 75 percent of the juvenile CV spring-run Chinook salmon of a year's cohort would be exposed to conditions of a spring pulse flow. Given the uncertainty of actual forecasting, we assume May 1 Shasta storage of 4 MAF would occur less frequently than the 75 percent probability provided in the modeling.

Species response to a spring pulse would be decreased travel time for juveniles, affecting survival (improved Flow Conditions), and a temporary increase in riparian habitat accessibility (reducing the Loss of Natural River Morphology and Function). Because the spring pulse period also overlaps with adult CV spring-run Chinook salmon upstream migration in March — September (Yoshiyama et al. 1998), the spring pulses are also expected to have the beneficial effects of reducing water temperatures (improved Water Temperature) and improving passage (reduced Passage Impediments/Barriers). A spring pulse flow could have a mitigating effect on the stressors related to water operations by improving Flow Conditions and reducing the effect of the Loss of Natural River Morphology and Function stressor.

With relation to the stressors Loss of Riparian Habitat and Instream Cover and Loss of Floodplain Habitat, NMFS considers that the managed changes in the hydrograph can alter access to riparian habitat and instream cover in the immediate area of releases but perhaps moreso further downstream (e.g., altered frequency of inundation of side channels, floodplains, and overtopping of flood system weirs into the Sutter and Yolo bypasses). The flows provided by a spring pulse can lessen the effects of these stressors, but we note that the frequency of pulses may limit the reduction of these stressors.

The exposure, risk, and response of CV spring-run Chinook salmon to the Spring Pulse Flows component of the PA is summarized with similar information for other species in Table 2.5.2-11.

2.5.2.3.2.3.3 CCV Steelhead Exposure, Response, and Risk

Although relatively small run sizes have limited the number of direct observations, the Knights Landing RST data from the last 15 years show a large proportion of juvenile CCV steelhead in the lower Sacramento River from March 1 to May 15. These fish would experience the effects of a spring pulse flow. By March 1, 25 to 50 percent of juvenile CCV steelhead will have passed Knights Landing, migrating into the Delta. Depending on when a pulse flow is implemented, up to 50 to 75 percent of the steelhead juveniles of a year's cohort would be exposed to conditions of a spring pulse flow. Given the uncertainty of actual forecasting, we assume May 1 Shasta storage of 4 MAF would occur less frequently than the 75 percent probability provided in the modeling.

Similar to other species, CCV steelhead response to a spring pulse would be decreased travel time for juveniles improving survival (improved *Flow Conditions*) and a temporary increase in riparian habitat accessibility (reducing the *Loss of Natural River Morphology and Function*). The spring pulse period does not overlap significantly with adult CCV steelhead migration, which occurs predominately July through December (McEwan 2001).

The exposure, risk, and response of steelhead to the Spring Pulse Flows component of the PA is summarized in Table 2.5.2-11.

2.5.2.3.2.3.4 sDPS Green Sturgeon Exposure, Response, and Risk

sDPS green sturgeon adult migration and spawning timing is such that a large proportion of green sturgeon are expected to be in the mainstem Sacramento River in March through July (Poytress et al. 2015). The proposed spring pulse flow would occur from March 1 to May 15 if implemented. Given the uncertainty of actual forecasting, it is likely that May 1 Shasta storage of 4 MAF would occur less frequently than the 75 percent probability provided in the modeling. NMFS is therefore uncertain in the frequency of the implementation of a spring pulse flow and assumes that it would occur in fewer than 75 percent of years.

Because the spring pulse flow would better characterize the natural hydrograph for the Sacramento River, adult sDPS green sturgeon would be expected to experience periods during which the spring pulse flow would mitigate the effects of the otherwise altered hydrograph resulting from the PA. For the years a spring pulse flow occurs, we expect temporarily improved conditions conducive to spawning and migration by reducing *Passage Impediments/Barriers to Migration* and increasing the frequency of high flow events, which are otherwise limited (*Altered Flow*).

The exposure, risk, and response of sDPS green sturgeon to the Spring Pulse Flows component of the PA is summarized in Table 2.5.2-11.

Table 2.5.2-11. Summary Exposure, Response, Risk table for species and life-stages affected by stressors of Spring Pulse Flows. Information provided by Reclamation supplemental BA information.

Species	Life- stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
Winter- run Chinook salmon	Adult	Large	<75% of years	 Flow Conditions, Loss of Natural River Morphology and Function Passage Impediments/Barriers Loss of Riparian Habitat and Instream Cover Loss of Floodplain Habitat 	 Increased reproductive success Reduced survival probability
Winter- run Chinook salmon	Egg	Small - Medium (<2% - 6%)	<75% of years	Water Temperatures	Reduced survival probability
CV spring- run Chinook salmon	Juveniles, Adult	~75% (Large), Large	<75% of years	 Flow Conditions, Loss of Natural River Morphology and Function Passage Impediments/Barriers Loss of Riparian Habitat and Instream Cover Loss of Floodplain Habitat 	 Increased survival probability Increased reproductive success
CCV steelhead	Juveniles	50% - 75% (Medium)	<75% of years	 Flow Conditions, Loss of Natural River Morphology and Function 	 Increased survival probability Increased reproductive success

Species	Life- stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
sDPS green sturgeon	Adult	Large	<75% of years	 Altered Flow, Passage Impediments/Barriers to migration 	 Increased reproductive success Increased lifetime reproductive success

2.5.2.3.2.4 Spring Management of Spawning Locations

Reclamation has proposed continued coordination with NMFS to establish research to determine if maintaining colder water earlier in the year induces earlier spawning, or if warmer April/May Sacramento River temperatures induces later spawning. This consideration is based on emerging research that indicates the spawning timing of winter-run Chinook salmon may be influenced by water management decisions that are intended to conserve cold water for use during the summer temperature management season (Johnson et al. 2017, Windell et al. 2017). Specifically, there is evidence that higher April water temperatures correspond to increased and delayed spawning in July and August (Hendrix et al. 2017) (Figure 2.5.2-18). However, with little description of this action component or how it may affect the species, there is insufficient information available to assess the effects or to determine how the action component would be incorporated into Reclamation's operations.

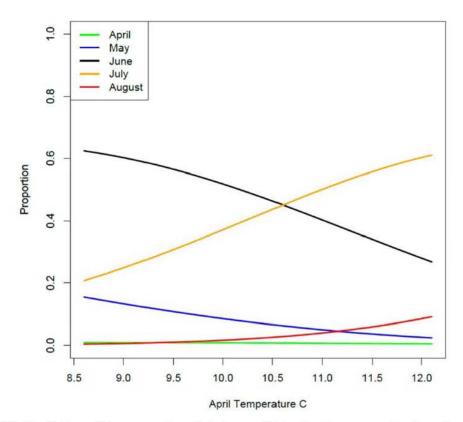


Figure 2.5.2-18. Predictions of the proportion of winter-run Chinook salmon spawning from the multinomial regression model using April temperatures at Keswick Dam as a predictor value. From Hendrix et al. (2017).

In order to provide enough certainty that the PA component would be implemented, and to assess its effects, this component of the PA will need to be developed further. This information should include an experimental design to know what operation is required for the evaluation. Because this information is not included, NMFS is not able to analyze effects to the species, either site-specifically or programmatically, and its effects are not included in this Opinion.

2.5.2.3.3 Shasta Summer Operations

During the summer, Reclamation's operational considerations are primarily flows required for Delta outflows, instream demands, and temperature control downstream of Keswick Dam. These underlying operational considerations remain the same for both the COS and the PA.

The PA includes the Delta Smelt Summer-Fall Habitat action component, which proposes to use structured decision-making to annually implement habitat actions that support Delta Smelt recruitment in the summer and fall (June through October). This action is intended to maintain low salinity habitat in the estuary when water temperatures are suitable, manage the low salinity zone to overlap with turbid water and available food supplies; and establish a contiguous low salinity habitat through the estuary. This is proposed as a collaborative planning action. The PA identifies that Reclamation intends to provide any needed Delta outflow augmentation in the fall primarily through export reductions, but that storage releases from upstream reservoirs may be

used to initiate the action by pushing the salinity out further in August and early September. The need for this initial action will depend on the particular hydrologic, tidal, storage, and demand conditions at the time. To the extent that the effects of this action are within the operations characterized by the Shasta summer operations, take is authorized for the Delta Smelt Summer-Fall Habitat action component in this Opinion.

2.5.2.3.3.1 Summer Cold Water Pool Management

Reclamation proposes to address Summer Cold Water Pool Management using a four-tier strategy that allows for strategically selected temperature objectives based on projected total storage and cold water pool, meteorology, Delta conditions, and species needs. The tiered strategy recognizes that cold water may be a limited resource that Reclamation should manage to achieve desired water temperatures for fisheries objectives. Actual operations will depend upon the available cold water and modeling. In any given year, the PA states that cold water pool and storage could result in Reclamation switching between Tiers within the year if needed to optimally use the cold water pool. However, considering information provided by Interior on May 20, 2019, and discussions with Reclamation on May 22, 2019, NMFS assumes that once the initial tier is selected on May 1, Reclamation will not cause Shasta CWP management to shift into a warmer tier during real-time implementation of the Shasta Cold Water Management Plan except in the event of responding to emergency and/or unforeseen conditions. Furthermore Reclamation will use various operational flexibilities and/or contingency actions after May 1, potentially including adjusting initial allocations, to stay within a Tier, unless the change is caused by events outside Reclamation's control or beyond what was planned for in the temperature management plan. Figure 2.5.2-19 (Figure 4-4 from the ROC on LTO BA) provides a decision tree explaining the decision points for Shasta Reservoir temperature management.

The initial determination of operational Tier for an upcoming summer is based on the available storage on May 1 and temperature modeling of conditions at that time. Figure 2.5.2-3 was provided by Reclamation to describe the assumed relationship between total Shasta storage on May 1, corresponding cold water (i.e., less than 52°F) pool availability, and an estimated daily average temperature at CCR that could be met during the summer temperature management period of May 15-October 31. The PA indicates that Reclamation has based the development of the cold water pool management Tiers on recent history of Sacramento River temperature management below Keswick Dam.

Using the information reflected in Figure 2.5.2-3, Reclamation has identified the following definitions of operational Tiers:

- Tier 1: May 1 more than 2.8 MAF of cold water pool in Shasta Reservoir or modeling suggests that a daily average temperature of 53.5°F at CCR can be maintained from May 15 to October 31;
- Tier 2: May 1 cold water pool volume between 2.3 and 2.8 MAF or modeling suggests that the 53.5°F at CCR cannot be maintained from May 15 to October 31;
- Tier 3: May 1 cold water pool less than 2.3 MAF or modeling suggests that maintaining 53.5°F at CCR would have higher mortality than a warmer temperature; and
- Tier 4: May 1 total storage less than 2.5 MAF or if Reclamation cannot meet 56°F at CCR.

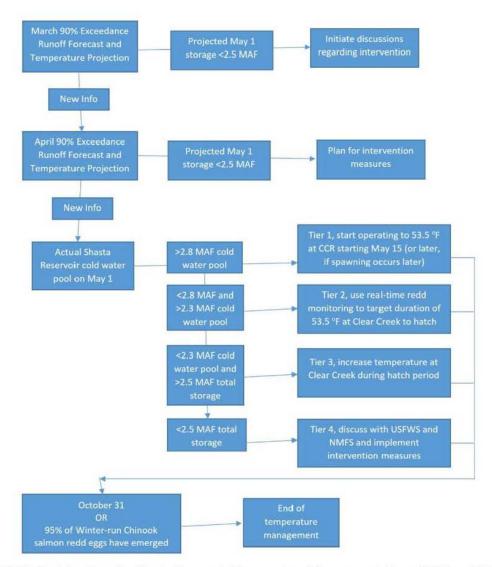


Figure 2.5.2-19. Decision Tree for Shasta Reservoir Temperature Management. From ROC on LTO BA (Figure 4-4).

In using the BA modeling to support the analysis of effects to the species, NMFS notes that the certainty of operating in any Tier is dependent on the accuracy of the characterization of the operations in the PA modeling and the ability of actual operations to commit to the operations as characterized in the modeling. Based on the 82-year historical sample set used in the CalSimII modeling of the PA, Shasta storage conditions over the long-term would designate Tier 1 operations in 68 percent of years, Tier 2 operations in 17 percent of years, Tier 3 operations in 7 percent of years, and Tier 4 operations in 7 percent of years. To better address the uncertainty associated with the frequency of operating in each Tier, NMFS considered the historical record of Shasta storage. Historically, May 1 Shasta storage is 4.1 MAF less frequently than the CalSimII modeling predicts for the PA. Table 2.5.2-12 shows the proportion of years May 1 Shasta storage is equal to or greater than 4.1 MAF over different periods of Shasta Dam's history.

Table 2.5.2-12.	Proportion of years in w	hich Shasta total storage	is greater than or equal	to 4.1 MAF on May
1.				

Period considered	Percent of time storage is greater than 4.1 MAF	Limit of readily available data New Melones and D-1485 to present		
1953-2018	57%			
1980-2018	49%			
1996-2018 52%		D-1641 to present		
2010-2018	62%	NMFS 2009 Opinion to present		

As proposed in the PA, implementation of temperature management would start after May 15, or when the monitoring working group determines, based on real-time information, that winter-run Chinook salmon have spawned, whichever is later. Since the Tier determination is intended to be based on the May 1 storage value and modeling of anticipated conditions, NMFS notes that there is at least a 15-day period in which storage may be affected by reservoir releases and inflows. This introduces a component of uncertainty to the ability of the determined Tier operation to meet temperature management objectives later in the management season.

Additionally, NMFS notes that there is a lag time in the detection of the first winter-run Chinook salmon spawning which would lead to a delay in the onset of temperature management. Aerial redd surveys are typically conducted on a weekly (or longer) basis, so redds constructed on the same day as an aerial redd survey may not be detected for a week or more. In addition, adult Chinook salmon die approximately 10 days after spawning, so when a Chinook salmon carcass is detected, redd construction likely occurred approximately 10 days earlier. Therefore, the onset of temperature management could be 7-10 days, or more, later than the actual onset of spawning. The onset of spawning is especially important in the implementation of Tiers 2 and 3, when Reclamation proposes to center temperature management on the projected time period when the winter-run Chinook salmon eggs have the highest dissolved oxygen requirement (37–67 days post fertilization). Finally, NMFS notes that Reclamation's proposed onset of temperature management (i.e., based on real-time monitoring of redd timing) indicates that spawning at the LSNFH is not considered. There have been years where spawning at LSNFH occurred prior to the first detection of winter-run Chinook salmon spawning in the Sacramento River. The challenge of managing this information and response, given limitations of monitoring, is expected to be addressed in the development of temperature management plans and through the the SRTTG process.

As proposed in the PA, temperature management would conclude October 31, or when the monitoring working group determines based on real-time monitoring that 95 percent of winterrun Chinook salmon alevin have emerged, whichever is earlier. NMFS notes that existing monitoring methods likely will not be able to indicate the date of 95 percent redd emergence. Aerial redd surveys can only detect shallow redds, and carcass surveys monitor only a portion of the run. Only when final escapement estimates are provided in November is there an estimate of the number of females; even with that information, it is not possible to know when 95 percent of the redds were constructed, which would be required to know date of emergence. NMFS,

therefore, expects that temperature management will not extend beyond October 31. This may result in underestimating temperature dependent mortality, depending on November meteorological conditions.

Reclamation proposes to operate the TCD at Shasta Dam to continue providing temperature management in accordance with CVPIA 3406(b)(6) while minimizing impacts on power generation. Cold water pool is defined as the volume of water in Shasta Reservoir that is cooler than 52°F. Reclamation would determine this volume based on monthly (or more frequent) reservoir temperature profiles.

The thresholds used in this Opinion for temperature effects on the life-stages of salmonids are described in the EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003). The guidance was jointly developed by EPA, USFWS, NMFS, States, and Tribes in the Pacific Northwest. They examined the most recent science at that time on the temperature effects on salmonid physiology and behavior, the combined effects of temperature and other stressors on threatened fish stocks, the pattern of temperature fluctuations in the natural environment, and other relevant issues. The project culminated in 2003 with the EPA publication of guidance recommendations to States and Tribes on how they can designate uses and establish temperature numeric criteria for waterbodies to protect coldwater salmonid species in the Pacific Northwest. Although based on species in the Pacific northwest, EPA (2003) provides general guidance for salmonid temperature maximum conditions.

The EPA temperature recommendations are currently the most robust management targets for use in the Central Valley. The guidance is the result of a multi-year, multi-agency synthesis with contributions from three states, four federal agencies, five tribes, two public review drafts and two independent scientific peer review panels. The recommendations include a technical synthesis and detailed examinations of temperature impacts on salmonid behavior and distribution, spatiotemporal temperature patterns in streams, interactions with other factors, and a summary of the technical literature examining the physiological effects of temperature on salmonids, including consideration of California salmonid studies ((Nielsen et al. 1994, Marine 1997, Marine and Jr. 1998, Myrick and Cech Jr 2000); and Orsi (1971) as cited in McCullough et al. (2001)). There is a long standing precedent that EPA (2003) represents the best available science for temperature recommendations and serves as the basis of biological opinions (CVP/SWP operations for Sacramento, American, and Stanislaus rivers, Spring Creek) and FERC proceedings (Feather and Tuolumne rivers) in the Central Valley.

EPA (2003) recommends a 13°C (55.4°F) maximum 7-day average of the daily maxima (7DADM) criterion for the protection of waterbodies used or potentially used for salmon and trout spawning, egg incubation, and fry emergence, and recommends that this use apply from the average date that spawning begins to the average date incubation ends (the first 7DADM is calculated one week after the average date that spawning begins). The 7DADM metric is recommended because it describes the maximum temperatures in a stream, but is not overly influenced by the maximum temperature of a single day. Thus, it reflects an average of maximum temperatures that fish are exposed to over a weeklong period.

Reclamation has noted that operating to the 7DADM metric is a less efficient use of the cold water pool because the week-long averaging period creates a lag between operations and the observed effect. However, without daily average temperature criteria derived from local

temperature tolerance studies, the EPA (2003) guidance provides the best available temperature tolerance criteria. The 7DADM of 55.4°F was used to identify an equivalent daily average temperature for use in management of temperature compliance. The Sacramento River above the Clear Creek (CCR) gauge is a surrogate for the downstream extent of most winter-run Chinook salmon redds. The critical temperature threshold being used as a management target is 53.5°F daily average temperature, which was identified as an indicator of the ability to meet the 55°F 7DADM, and Rombough (1988) identified it as the temperature above which increased egg mortality is observed in steelhead embryos. A more recent phenomenological assessment of temperature-dependent Chinook salmon egg mortality modeling calibrated to fry survival to Red Bluff concluded the critical temperature threshold for egg incubation in the river was 53.6°F daily average. Below that temperature, there was no observed mortality due to temperature (Martin et al. 2017). According to a recent independent review panel, the model holds "...considerable potential for resolving important links between the physico-chemical environment (e.g., temperature and oxygen levels) experienced by the earliest life stages of salmonids and their survival in the Sacramento River," and is a "...parsimonious and realistic representation of temperature effects on eggs" (Gore et al. 2018). However, the same review also noted that "Despite its strengths... model predictions of survival will have sizable uncertainty...[and] further research is needed to eliminate other possible explanations..." and suggested "...that temperature-related mortality should be distinguished from all other sources of mortality through the fry stage." Based on the studies in the Central Valley, and on studies of temperature requirements for Chinook salmon, temperatures from 39.2 to 53.6°F tend to produce relatively high survival to hatching and emergence, with approximately 42.8-50°F being optimum (Seymour 1956, Slater 1963, Healey 1979, Boles 1988b, U.S. Fish and Wildlife Service 1999, U.S. Environmental Protection Agency 2001, Myrick and Cech 2004). The egg temperature threshold of 53.5°F daily average temperature is also considered as the guidance establishing effects to CV spring-run Chinook salmon and CCV steelhead eggs and alevin.

The EPA (2003) guidance also specifies a maximum of 61°F 7DADM for adult salmon holding prior to spawning and juvenile "core" rearing, and a summer maximum temperature for salmon/trout migration of 68°F 7DADM. As with salmonids, water temperature during the early life stages is a key factor in green sturgeon recruitment and development. Van Eenennaam et al. (2005) found that the lethal temperature for developing embryos is approximately 22°C (71.5°F), with sublethal effects of abnormal development and reduced hatching success beginning to appear at 17.5°C (63.5°F) (Van Eenennaam et al. 2005).

Although our understanding of salmonid temperature tolerance continues to evolve since the publication of EPA (2003), a comparably robust synthesis that includes more recent studies is lacking, and additional studies specific to Central Valley populations are still needed. For example, some more recent studies of rainbow trout have noted that that the physiological mechanisms that determine critical thermal maxima in salmonids are highly conserved (Rodnick et al. 2004) but also that populations may be locally adjusted to temperature differences (Verhille et al. 2016). One of the most recent studies on the topic built on the work of Martin et al. (2017), demonstrating plasticity in acute thermal tolerance, interactions with hypoxia, and potential physiological tradeoffs, ultimately concluding that "This study, in addition to Martin et al. (2017), suggests that in natural redds where dissolved oxygen (DO) is variable, the target temperature of 56°F may be too high in some cases since salmon embryo mortality can occur at lower temperatures in hypoxia" (Del Rio et al. 2019). However, this study has not adequately

distinguished between shorter term acclimatization to the local conditions versus adaptation via genetic change across a population, nor demonstrated how to derive robust ambient temperature targets from physiological endpoints like aerobic scope. A literature review by the University of California at Davis currently being prepared for publication concluded that for most life-stages and species for which thermal performance data exist, the EPA (2003) guidelines appear to be protective against temperature-induced mortality for California salmonids. Although the guidelines may be sub-optimal and could use further refinement, in the absence of California-specific temperature guidance, the literature review recommended EPA (2003) guidance for use in California (Zillig et al. 2018)."

In order to use the EPA (2003) guidance in a meaningful way to assess the daily average temperatures described by Reclamation's HEC-5Q modeling, the 7DADM criteria need to be converted to monthly mean temperatures. Table 2.5.2-13 provides the conversion factors by month and location necessary to convert 7DADM to monthly mean temperatures that can be used to assess Reclamation's water operations effect on river temperatures. While capturing the mean of conditions observed during the available historical data, these relationships are affected by flow conditions and may be different for specific flows. These relationships are applied in temperature assessments in subsequent sections of this Opinion to convert daily average HEC-5Q data into 7DADM.

Table 2.5.2-13. Conversion Factors (°F) for EPA Seven-Day Average Daily Maximum Water Temperature Thresholds to monthly mean temperatures for specific locations in the Sacramento River based on available historical data¹. Table excerpted from Appendix 5.D, Quantitative Methods and Detials Results for Effect Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale of the Biological Assessment for the California WaterFix (U.S. Bureau of Reclamation 2016a).

Month	Keswick	Clear Creek	Balls Ferry	Bend Bridge	Red Bluff	Wilkins Slough ²
January	-0.36	-1.01	-0.75	-0.67	-0.86	0.0
February	-0.28	-1.11	-0.86	-0.62	-0.97	-0.3
March	-0.17	-1.29	-0.94	-0.66	-1.23	-0.3
April	-0.25	-1.66	-1.47	-0.95	-1.55	-0.6
May	-0.36	-1.73	-2.18	-1.59	-1.47	-1.4
June	-0.32	-1.55	-2.25	-1.87	-0.96	-1.2
July	-0.36	-1.41	-2.18	-2.01	-0.90	-1.3
August	-0.43	-1.74	-2.06	-1.61	-0.94	-1.3
September	-0.30	-2.00	-1.76	-1.16	-1.70	-2.0
October	-0.25	-1.73	-1.25	-0.91	-1.83	-1.4
November	-0.38	-1.37	-1.10	-0.99	-1.53	-1.3
December	-0.82	-1.42	-1.30	-1.24	-1.48	-1.0

¹Based on historical data from 2003-2014 for all sites except Wilkins Slough, which is based on historical data from November 2012 through June 2015. For a given location and month, values in this table were added to 7DADM thresholds identified for the particular life stage such that actual thresholds used in the evaluation for each month were lower than those identified.

Temperature effects associated with implementation of the tiered strategy are described according to the likelihood of Reclamation operating in a particular Tier (based on the modeled May 1 storage). The conditions experienced by the species are then described by the likelihood of exceeding a temperature threshold within a Tier. In Section 2.5.2.1 Shasta Annual Operations, we identified uncertainties regarding the PA's ability to provide temperatures suitable for salmon holding, spawning, egg incubation and rearing from May 15 to October 31. In part, these uncertainties are attributed to the consideration of modeling limitations, alternative analytical tools, and real-time implementation of the proposed action. Figure 2.5.2-20 below shows examples of water temperatures at CCR for the four Tiers. The proposed Tiers are described below, along with storage levels that indicate the available cold water for each Tier. NMFS notes that Figure 2.5.2-20, which was provided by the Reclamation in the ROC on LTO biological assessment, is not to scale and does not provide an accurate pictorial proportional depiction of temperature target operations during the summer temperature management season.

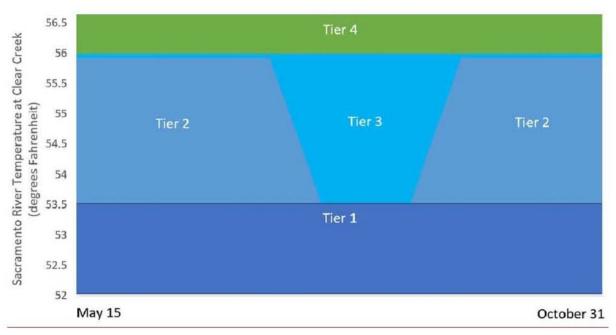


Figure 2.5.2-20. Depiction of temperature target operations according to Reclamation's tiered approach. From ROC on LTO BA (Figure 4-3).

Tier 1

Reclamation proposes to operate to a daily average temperature of 53.5°F at the CCR gauging station in years when Reclamation determines that cold water pool is sufficient to manage summer temperatures (i.e., more than 2.8 MAF of cold water pool in Shasta Reservoir at the

²Because there is no flow gauge at Knights Landing, Wilkins Slough data were used to calculate the conversion factor for Knights Landing.

beginning of May or modeling suggests that a daily average temperature of 53.5°F at CCR can be maintained from May 15 to October 31). A cold water pool volume of 2.8 MAF approximates to 4.1 MAF total storage at the end of April. Based on the CalSimII 82-year historic sample set, Shasta end of April storage is greater than or equal to 4.1 MAF in 68.3 percent of years. However, under certain conditions, operations can change from one Tier to either a higher or lower Tier within a management season, and NMFS notes that Shasta Reservoir storages can change notably from May 1 to June 1 given early summer depletions and diversions. This introduces an uncertainty into maintaining operations of the determined Tier throughout the management season and the expected late-season temperature performance of an identified Tier. NMFS considers that Reclamation intends to use various operational flexibilities and/or contingency actions after May 1, potentially including adjusting initial allocations, to stay within a Tier, unless the change is caused by events outside Reclamation's control or beyond what was planned for in the temperature management plan.

Tier 2

In years when cold water pool is insufficient to allow Tier 1 (i.e., less than 2.8 MAF of cold water pool in Shasta Reservoir at the beginning of May or modeling suggests that the 53.5°F at CCR cannot be maintained from May 15 to October 31), Reclamation proposes to optimize use of cold water for protection of winter-run Chinook salmon eggs based on lifestage-specific requirements. This would reduce the duration of time operating to 53.5°F target temperatures compared to Tier 1. Water temperatures at CCR would vary based on real-time monitoring of redd timing and lifestage-specific temperature dependent mortality models such as Anderson (2018). The 53.5°F target temperature at CCR would be centered on the projected time period of greatest dissolved oxygen concentration requirement for winter-run Chinook salmon eggs (i.e., 37–67 days post-fertilization). When May 1 cold water pool is equal to or less than 2.79 MAF, Reclamation proposes to operate to 53.5°F from 37 days after the first observed redd to 67 days after the last observed redd, as long as this is earlier than October 31. The duration of the 53.5°F protection will decrease in proportion to the available cold water pool on May 1; however, the PA does not specify the details of this decrease in duration. Reclamation will determine this time period by evaluating different temperature scenarios using the latest egg mortality model(s) and real-time monitoring of redds. For the summer temperature management period outside of the lifestage-specific target, Reclamation proposes to operate to CCR daily average temperatures up to but no warmer than 56°F. Based on the CalSimII 82-year historic sample set, Shasta end of April storage is less than 4.1 MAF, but greater than about 3.5 MAF (equivalent to a cold water pool of 2.3 MAF), in about 17 percent of years. While NMFS can use this expectation in analyses of frequency of Tier 2 operations, we note that this may not be an accurate characterization of Tier probability and that operations can, in certain circumstances, change from one Tier to either a higher or lower tier within a management season.

Tier 3

As identified in the PA, Reclamation may determine that the lifestage-specific temperature targets of Tier 2 cannot be met. Tier 3 is the proposed operation when cold water pool in Shasta Reservoir on May 1 is less than 2.3 MAF or when modeling suggests that maintaining 53.5°F at CCR would have higher mortality than a warmer temperature. Reclamation proposes to use cold water pool releases to maximize winter-run Chinook salmon egg survival by increasing the

coldest water temperature target. At the highest storage levels in Tier 3, the targeted temperature at CCR is proposed to be a daily average of 53.5°F; as storage decreases, operations would target an increased lifestage-specific temperature period up to 56°F. Additionally, the shoulder periods around the lifestage-specific period could also be operated to a 56°F target. Reclamation proposes to increase the temperature while minimizing adverse effects to the greatest extent possible, as determined by the analyses using egg mortality models, real-time monitoring, and expected and current water availability. This Tier would be in effect until Reclamation could no longer meet 56°F at CCR at which point Reclamation would shift to Tier 4. Because the increase in lifestage-specific target is not explicitly defined, this component of the PA has a notable uncertainty its effect to species. NMFS notes that the likely operational temperature target for this Tier has not yet been identified or proposed; it could range from 53.5°F to 56°F, and may even be no less than 56°F throughout the temperature season. In keeping with the principle of institutionalized caution, our analysis and assumptions generally do not impose the effects of uncertainty onto the species, and therefore our analysis considers the least protective of operations for this Tier.

Based on the CalSimII 82-year historic sample set, Shasta end of April storage is less than 3.5 MAF, but greater than about 2.5 MAF, in about 7 percent of years. While NMFS can use this expectation in analyses of frequency of Tier 3 operations, we note that this may not be an accurate characterization of Tier probability and that operations can, in certain circumstances, change from one Tier to either a higher or lower tier within a management season.

Tier 4

Operations for Tier 4 are defined by mid-March storage and operations forecasts of Shasta Reservoir total storage less than 2.5 MAF at the beginning of May, or if Reclamation cannot meet 56°F at CCR. In this instance, Reclamation proposes to initiate discussions with USFWS and NMFS on potential intervention measures to address low storage conditions that continue into April and May (however, any benefits from implementation of these measures is not included in results presented below due to their inability to be characterized by the modeling). Reclamation proposes to perform an initial temperature model analysis in April after the DWR Bulletin 120 has been received and the operations forecast completed. This is the first month that a temperature model analysis is feasible based on temperature profiles. Prior to April, there is insufficient stratification in Shasta Reservoir to allow a temperature model to provide meaningful results. The April temperature model scenario is proposed to be used to develop an initial temperature plan for submittal to the SWRCB. This temperature plan may be updated as Reclamation has improved data on reservoir storage and cold water pool via the reservoir profiles at the end of May, and throughout the temperature control season. NMFS notes that the PA indicates that the plan will be provided to the SRTTG for review and comment, and NMFS assumes that the SRTTG is the means by which NMFS would would contribute to the development of this plan.

Based on the CalSimII 82-year historic sample set, Shasta end of April storage is less than 2.5 MAF in about 7 percent of years. While NMFS can use this expectation in analyses of frequency of Tier 4 operations, we note that this may not be an accurate characterization of Tier probability and that operations can, in some circumstances, change from one Tier to either a higher or lower Tier within a management season. This introduces uncertainty into the determination of effect of summer cold water pool management.

2.5.2.3.3.1.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

Winter-run Chinook salmon response to the Summer Cold Water Pool Management component of the PA is largely associated with temperature. Temperatures at or below the threshold of 53.5°F are not expected to have a biologically significant effect on spawning adults or egg survival. At temperatures greater than the 53.5°F threshold, there would be an increase in adult pre-spawn mortality and a decrease in egg survival. Both of these are related to the *Water Temperatures* stressor.

The Summer Cold Water Pool Management component of the PA is intended to coincide with winter-run Chinook salmon spawning and egg incubation. This is typically expected to occur in late April through October (Williams 2006), but in recent years the onset of spawning has been later in the season (National Marine Fisheries Service 2015d).

In addition to the spatial and temporal distribution of redds, a critical consideration in assessing the effects of increased temperature on redds and eggs is the length of time a redd is sensitive to temperature increases as it relates to minimum DO concentration requirements. In consideration of potential management applications, Anderson (2018) assesses three models of temperature dependent mortality, where Model I (i.e. the Martin et al. 2017 model) considers ageindependent thermal mortality with spatially-independent background mortality, Model II (i.e. the "Anderson model" used in this Opinion) considers age-dependent thermal mortality without any background mortality, and Model III which considers age-dependent thermal mortality and spatially-dependent background mortality. For this analysis Models I and II were considered, where the Anderson (2018) model assumes that redds/eggs are only sensitive to DO conditions in the five days before egg hatching (the "hatch model"), while the Martin et al. (2017) model considers temperatures and DO conditions from redd creation until fry emergence (the "emergence model"), which is a longer period. NMFS also considers that the Anderson model accounts for egg mortality only during the hatch period; background mortality and egg mortality resulting from higher water temperatures outside of the hatch period are not included in the application of this model. NMFS notes that the Anderson model could, therefore, underestimate mortality by not accounting for egg mortality prior to the hatch period in the calculated percentage mortality during the hatch period. NMFS also notes that the Anderson model is conceptual and has not been calibrated or peer reviewed. We acknowledge the uncertainties and needs for additional research identified in review of Martin et al. (2017), but also that it is a "parsimonious and realistic representation of temperature effects on eggs" (Gore et al. 2018). NMFS has considered external reviews and field-testing in discerning the weight of evidence applied to methods according to categories identified in Section 2.1 Analytical Approach. However, while NMFS considers the "emergence model" as representing the best available science for assessing temperature effects on salmonid eggs, to consider the effects of Shasta operations targeting the "hatch" period of egg development NMFS includes results for both models (hatch and emergence) in the following assessment. Inclusion of the Anderson (2018) "hatch model" results is exclusive to the assessment of Shasta temperature management, as the only action component of the PA based on Anderson (2018) are those related to Shasta operations.

Tier 1

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 1 operations apply as an initial target to summer temperature management in approximately

68 percent of years. This is generally consistent with the frequency of Shasta storage greater than or equal to 4.1 MAF on May 1 (see Table 2.5.2-12). However, the PA identifies that operations can change from one Tier to another within a management season in certain circumstances, and the modeling for the BA is limited in that it cannot indicate the extent to which Shasta storages may change from the May 1 assessment storage to the May 15 commencement of temperature management. Additionally, the greater increases in temperature projected by recent climate assessments (Section 2.1 Analytical Approach) are not reflected in these storage predictions.

NMFS also notes that HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 1 years, the 53.5°F threshold is exceeded 23.3 percent of days. NMFS acknowledges that these results do not include real-time adjustments to operations that could allow Reclamation to reduce the proportion of days exceeding the temperature threshold at CCR. Regardless of those real-time decisions and the year categorizations, we consider the modeling provided to be the most quantitative approach to evaluating effects and have analyzed them as such. Given these uncertainties, NMFS therefore assumes that the maximum frequency at which the initial determination of Tier 1 would apply is 68 percent of years. However, given the historical information in Table 2.5.2-12 showing that the Shasta total storage is greater than or equal to 4.1 MAF on May 1 in as few as 49 percent of years, NMFS considers the range of 49 to 68 percent of years.

The HEC-5Q results are inputs to both the Anderson and Martin egg mortality models. These results correspond to an estimated mean temperature dependent mortality in Tier 1 years of 5 percent and 6 percent for the Anderson and Martin models, respectively. The ranges of the 25^{th} and 75^{th} percentiles of results are zero to six percent for both models (Figure 2.5.2-21) and the standard deviations around the mean are ± 8 and ± 9 percent, respectively. These are averages of the dataset for the suite of Tier 1 years, which includes broad operational range.

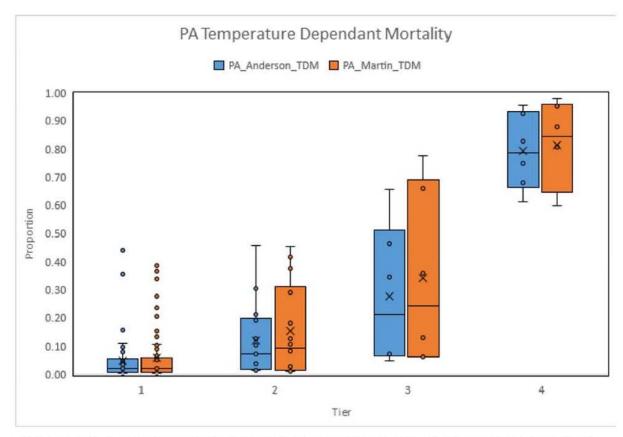


Figure 2.5.2-21. Temperature dependent mortality for each summer cold water temperature management Tier, as predicted for the Anderson model (blue) and the Martin model (orange). Figures show the range of values between the 25th and 75th percentiles (shaded box), the mean (x mark) the median (horizontal bar), and the range of expected values (whiskers). Outliers depicted as dots outside of the range of expected values are greater than 1.5 times the inter-quartile range between the 25th and 75th percentiles. Results are based on methods described by Reclamation in BA Appendix D. Both models are based on results of CalSimII modeling (82-year record), HEC5Q temperature modeling (same for both COS and PA), and an averaged spatio-temporal distribution of winter-run Chinook salmon redds as observed from 2007 – 2014.

Tier 2

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 2 operations apply as an initial early season target to summer temperature management in approximately 17 percent of years. However, NMFS analysis of historical data shows that the May 1 Shasta total storage would identify a Tier 2 year in as many as 35 percent of years. NMFS therefore considers the range of 17 to 35 percent of years. HEC-5Q modeling of the PA indicate that during the temperature management seasons of Tier 2 years, 53.5°F is exceeded 33.1 percent of days although the modeling does not capture real-time decision making which Reclamation expects will reduce the exceedance. This exposure corresponds to an estimated mean temperature dependent mortality in Tier 2 years of 12 percent and 15 percent for the Anderson and Martin models, respectively. The ranges of the 25th and 75th percentiles of results are 2 percent to 26 percent when considering both models (Figure 2.5.2-21), and the standard deviations

around the mean are ± 13 and ± 16 percent, respectively. These are averages of the dataset for the suite of Tier 2 years, which includes a broad operational range; Figure 2.5.2-14 shows that outside of the lifestage-specific target, Tier 2 operations could result in temperatures as low as 53.5° F or as high at 56° F.

NMFS notes that Tier 2 operations are centered on the projected time period of greatest dissolved oxygen concentration requirement for winter-run Chinook salmon eggs. However, the approach does not consider the uncertainty regarding initiation of spawning given inherent imprecision of monitoring efforts, as previously stated. Timing of weekly (or less frequent) aerial redd surveys could result in miscalculating the onset of the hatch period by up to a week or more. Similar risks are associated with basing this approach on information from carcass surveys, which assume that redd construction occurs ten days prior to carcass detection. Therefore, the onset of temperature management could be seven or more days later than the actual onset of spawning. The onset of spawning is especially important in the implementation of Tiers 2 and 3, when the PA proposes to center temperature management on the projected time period when the winter-run Chinook salmon eggs have the highest dissolved oxygen requirement. Because Tier 2 operations are proposed to be based on the timing of the hatch period, temperature-dependent egg mortality will likely be underestimated with the Tier 2 approach.

NMFS has evaluated associated side analyses to better consider the uncertainty associated with interpretation of the results of the different temperature-dependent egg mortality methods of the Anderson and Martin models. As proposed, temperatures outside of the lifestage-specific target time of Tier 2 could be as high as 56°F. A strict adherence to the warmest temperature timeseries defined by Figure 2.5.2-20 would result in temperatures at CCR of 56°F except during the lifestage-specific target period, during which temperatures would be 53.5°F. This is illustrated in the left plot of Figure 2.5.2-22.

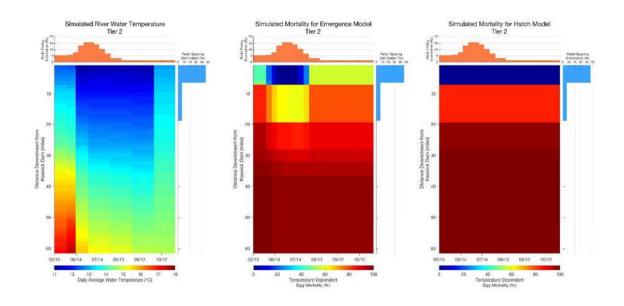


Figure 2.5.2-22. Simulated water temperature and temperature-dependent mortality in the upper Sacramento River for operation to highest temperatures within and outside of the lifestage-specific target period of Tier 2 summer temperature management.

The results of applying both the "emergence" and the "hatch" model to this temperature time series are shown in the middle and right plots of Figure 2.5.2-22. NMFS views this information as a worst-case characterization of a strict adherence to the warmest conditions allowed by the proposed operations defined for Tier 2, without moving to a different Tier during the summer temperature management season. It therefore serves as a contextual point of comparison of the range of effects that NMFS expects for years in which Tier 2 is maintained. NMFS notes that both models show lowest mortality during the "peak" of redd presence; the temperaturedependent mortality is less than 20 percent for both models in the mid-June through mid-July period. However, there is a notable discrepancy in the mortality for periods outside of this peak time of redd presence. The "emergence" model shows much greater temperature dependent mortality in the upper reaches earlier than mid-June and later than mid-July. Additionally, the hatch model estimates lower mortality in upper reaches than the emergence model, but greater mortality in lower reaches, where there are fewer redds (based on historical distribution). We note that the results of the emergence model shows mortality increases of nearly 60 percent in early August. This analysis shows the wide discrepancy for the different methods that have been used to assess effects of the operational range within a Tier. NMFS therefore considers the results of both models in our analysis and in support for understanding the difference in ranges of results shown in Figure 2.5.2-21.

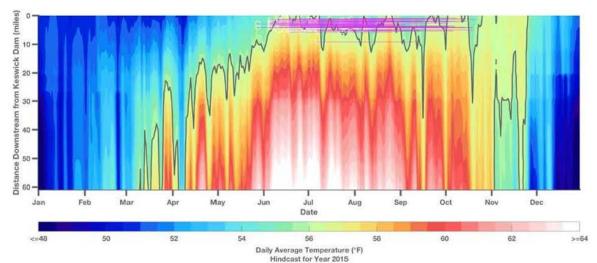
Tier 3

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately 7 percent of years. However, NMFS analysis of historical data shows that the May 1 Shasta total storage would

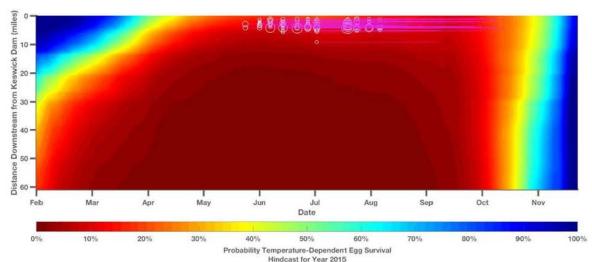
identify a Tier 3 year in as many as 15 percent of years. NMFS therefore considers the range of 7 to 15 percent of years. HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 3 years, 53.5°F is exceeded 65 percent of days, although the modeling does not capture real-time decision making which Reclamation expects will reduce the exceedance. This exposure corresponds to an estimated temperature-dependent mortality in Tier 3 years of 28 percent and 34 percent for the Anderson and Martin models, respectively. The ranges of the 25th and 75th percentiles of results are 7 to 59 percent when considering both models (Figure 2.5.2-21), and the standard deviations around the mean are ±25 and ±31 percent, respectively. These are averages of the dataset for the suite of Tier 3 years, which includes a broad operational range. The PA indicates and Figure 2.5.2-14 shows that Tier 3 operations could result in temperatures as low as 53.5°F or as high at 56°F, the lifestage-specific target may shift based on storage conditions, and the operational Tier could shift to Tier 4 during the summer temperature management season.

In evaluating effects of Tier 3, NMFS considered knowledge gained from operations in recent dry years. Due to a lack of sufficient cold water pool in Shasta Reservoir in 2014 and 2015, Sacramento River water temperatures rose to sublethal and lethal levels contributing to very low egg-to-fry survival of juvenile winter-run Chinook salmon estimated to pass RBDD in brood years 2014 (5.6 percent) and 2015 (4.2 percent), well below the 18-year average of 23.6 percent survival. Operations during 2014 began with low storage (approximately 2.18 MAF for May 1 based on historical data) and largely maintained 56°F at Balls Ferry for a portion of the temperature management season. However, storage levels were very low – down to 1.85 MAF in early June – which resulted in upper gates being above the water line and unavailable for use early in the season. The required earlier access to the full side gates (and resulting early release of the cooler water at that level) resulted in water temperatures that increased later in the season because there was less cold water to access at that time. This increased exposure of redds to lethal temperatures and contributed to the 5.6 percent egg-to-fry survival rate.

For 2015, May 1 storage of approximately 2.66 MAF would have arguably required designation of a Tier 3 management approach. While an initial May temperature management plan was established for that season, warmer temperatures and reduced inflow required that the plan be revised. The revised plan targeted a temperature of 57°F at the CCR gage (not to exceed 58°F unless required to conserve cold water pool based on real-time temperature management team guidance). The resulting average daily temperatures at CCR for the 2015 temperature management season of May to October was 56.7°F; these conditions resulted in a modeled winter-run Chinook salmon temperature-dependent survival of 14.6 percent (or conversely, 85.4 percent temperature-dependent mortality) and an observed egg to fry survival of 4.2 percent (National Marine Fisheries Service 2017c). Figure 2.5.2-23 shows a hindcast of the temperature landscape and temperature-dependent mortality conditions for 2015 downstream of Keswick Dam. These figures show that despite an end of April storage indicating a Tier 3 management approach, which BA modeling suggests would be expected to result in mean temperaturedependent mortality of 34 percent and 63 percent for the Anderson and Martin models, respectively, the proportion of redds exposed to temperatures in excess of 56°F was significantly larger. NMFS, therefore, has included in the analysis that the modeled estimates of mortality likely considerably underestimate observed estimates of mortality.



Note: Redd deposition dates are shown with white circles (size scaled by number of redds), and magenta lines represent date till emergence



Note: Redd deposition dates are shown with white circles (size scaled by number of redds), and magenta lines represent date till emergence

Figure 2.5.2-23. Hindcasted water temperature (°F) (top) and temperature-dependent mortality (bottom) landscape plots for 2015 downstream of Keswick Dam. Redd deposition dates are shown with white circles (size scaled by number of redds) and magenta lines represent date until emergence. Data and figures provided by SWFSC.

Tier 4

Based on the CalSimII modeling of May 1 Shasta storage, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately 7 percent of years. However, NMFS analysis of historical data shows that the May 1 Shasta total storage would identify a Tier 4 year in as many as 5 percent of years. NMFS therefore considers the range of 5 to 7 percent of years. HEC-5Q modeling of the PA indicates that during the temperature

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management seasons of Tier 4 years, 53.5° F is exceeded 86 percent of days. This exposure corresponds to an estimated temperature-dependent mortality in Tier 4 years of 79 percent and 81 percent for the Anderson and Martin models, respectively. The ranges of the 25^{th} and 75^{th} percentiles of results are 70 to 93 percent when considering both models (Figure 2.5.2-21), and the standard deviations around the mean are ± 14 and ± 16 percent, respectively. These are averages of the dataset for the suite of Tier 4 years, which includes a nearly undefined operational range.

The PA includes description of intervention measures intended to minimize or mitigate the effects of conditions and operations associated with the Tier 4 years. These measures would be triggered by low storage conditions and include consulting with USFWS and NMFS, increasing hatchery intake, adult rescue, and juvenile trap and haul. The proposed components are discussed in Section 2.5.2.5.3 Intervention Measures of this Opinion.

Effects of this component of the PA on winter-run Chinook salmon are condensed and summarized in Table 2.5.2-14.

Table 2.5.2-14. Summary Exposure, Risk, Response table for winter-run Chinook salmon life-stages affected by stressors of Summer Cold Water Pool Management.

Tier	Life-stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)				
1	Adult (holding), Egg/Fry	23.3% of days (Medium)	45-68% of years	Water Temperature	 Reduced reproductive success Reduced survival probability (mean temperature dependent mortality of 5 percent (Anderson) and 6 percent (Martin); standard deviation for the 2 different models is ±8 and ±9 percent) 				
2	Egg/Fry	33.1% of days (Medium)	17-35% of years	Water Temperature	 Reduced survival probability (increase in mean temperature dependent mortality of 12 percent (Anderson) and 15 percent (Martin); standard deviation for the 2 different models is ±13 to ±16 percent) 				
3	Egg/Fry	65% of days (Medium)	7-15% of years	Water Temperature	 Reduced survival probability (increase in mean temperature dependent mortality of 28 percent (Anderson) and 34 percent (Martin); standard deviation for the 2 different models is ±25 to ±31 percent) 				

4	Egg/Fry	86.3% of days (Medium)	5-7% of years	Water Temperature	•	Reduced survival probability (increase in mean temperature dependent mortality of 79 percent (Anderson) and 81 percent (Martin); standard deviation for the 2 different models is ± 14 to ± 16 percent) The above does not consider any effects (positive or negative) associated with the intervention measures
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2.5.2.3.3.1.2 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

As with winter-run Chinook salmon, CV spring-run Chinook salmon response to the Summer Cold Water Pool Management component of the PA is primarily associated with temperature. Temperatures above the 61°F 7DADM threshold for salmon adult holding can affect the timing of key processes such as spawning or can lead to stress, disease, bioenergetic depletion, or death. Exposure to high temperatures just prior to spawning can affect gametes held internally in adults, resulting in a loss of viability that appears as poor fertilization or embryo survival (U.S. Environmental Protection Agency 2003). Temperatures above the 53.5°F threshold would cause decreased egg survival (*Water Temperatures* stressor).

The start of the Summer Cold Water Pool Management component of the PA corresponds to the very first few CV spring-run Chinook salmon adults passing RBDD during their upstream migration. In dry years about 10 percent of returning CV spring-run Chinook salmon adults will have passed upstream of the RBDD by May 15, while in wet years less than 5 percent will have passed (Vogel and Marine 1991). Adult migration into the Sacramento River tributaries of Mill, Deer, and Butte creeks typically ends mid-July or August (Lindley et al. 2004). Once CV spring-run Chinook salmon reach the upper reaches of the river adults will hold prior to spawning, a period that continues until September. CV spring-run Chinook salmon spawning occurs August – October (Yoshiyama et al. 1998), with CDFW aerial redd surveys from 2003 - 2014 indicating that about 84 percent of redds are constructed upstream of Balls Ferry. Given the timing and distribution of redds, a large proportion of the CV spring-run Chinook salmon redds and eggs would be exposed to the conditions associated with Summer Cold Water Pool Management.

Tier 1

The likelihood of Reclamation implementing Tier 1 operations for Summer Cold Water Pool Management for CV spring-run Chinook salmon is the same as it is for winter-run Chinook salmon. NMFS notes that HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 1 years, the 61°F threshold for salmon adult holding prior to spawning is not exceeded during the temperature management season (May 15 - October 31) at Balls Ferry. As discussed earlier, the 61°F threshold is based on the 7DADM criteria described in the U.S. Environmental Protection Agency (2003) Region 10 water quality guidance. The 7DADM temperature roughly equates to a daily average temperature threshold that ranges between 2.25 - 1.25°F cooler, as shown in Table 2.5.2-13. With the converted daily average temperature, HEC-5Q modeling results indicate that during the temperature management seasons

of Tier 1 years, the DAT threshold at Balls Ferry for salmon adult holding prior to spawning is exceeded in about 1 percent of days. Modeled temperatures during the CV spring-run Chinook salmon spawning period (August – October) indicate that during the temperature management season of Tier 1 years, the 53.5°F threshold is exceeded 76 percent of days at Balls Ferry.

Tier 2

As described for winter-run Chinook salmon, Reclamation would determine that Tier 2 operations apply as an initial early season target in approximately 17 percent of years. HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 2 years, adult CV spring-run Chinook salmon migrating and holding prior to spawning would be exposed to temperatures in excess of the 61°F 7DADM threshold at Balls Ferry (when converted to a DAT threshold) in about 1 percent of days in Tier 2 years. Over the course of the spawning season (August – October) modeling shows CV spring-run Chinook salmon redds are exposed to temperatures greater than the egg incubation threshold of 53.5°F in about 80 percent of days during Tier 2 operations. NMFS notes that this is only four percentage points greater than the probability of exposure to temperatures greater than 53.5°F during Tier 1 years.

Tier 3

As described for winter-run Chinook salmon, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately 7 percent of years. The HEC5Q modeling of the PA indicates that during the temperature management seasons of Tier 3 years, adult CV spring-run Chinook salmon migrating and holding prior to spawning would be exposed to temperatures in excess of the 61°F 7DADM threshold at Balls Ferry (when converted to a DAT threshold) in about 13 percent of days in Tier 3 years. Over the course of the spawning season (August – October) modeling shows CV spring-run Chinook salmon redds are exposed to temperatures greater than the egg incubation threshold of 53.5°F in about 97 percent of days at Balls Ferry.

Tier 4

As described for winter-run Chinook salmon, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately 7 percent of years. The HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 4 years, adult CV spring-run Chinook salmon migrating and holding prior to spawning would be exposed to temperatures in excess of the 61°F 7DADM threshold at Balls Ferry (when converted to a DAT threshold) in about 36 percent of days in Tier 3 years. During the spawning period (August – October) modeling shows CV spring-run Chinook salmon redds are exposed to temperatures greater than the egg incubation threshold of 53.5°F in about 100 percent of days at Balls Ferry.

Effects of this component of the PA on CV spring-run Chinook salmon are condensed and summarized in Table 2.5.2-15.

Table 2.5.2-15. Summary Exposure, Risk, Response table for CV spring-run Chinook salmon life-stages

affected by stressors of Summer Cold Water Pool Management.

Tier	Life-stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
1	Adult (holding, spawning) , Egg/Fry	1% of days >61°F (Medium), 76% of days >53.5°F (Aug – Oct.) (Large)	45-68% of years	Water Temperature	 Reduced reproductive success Reduced survival probability
2	Adult (holding, spawning) , Egg/Fry	1% of days >61°F (Small) 80% of days >53.5°F (Aug – Oct.) (Large)	17-35% of years	Water Temperature	Reduced reproductive success Reduced survival probability
3	Adult (holding, spawning) , Egg/Fry	13% of days >61°F (Medium) 97% of days >53.5°F (Aug – Oct.) (Large).	7-15% of years	Water Temperature	 Reduced reproductive success, Reduced survival probability
4	Adult (holding, spawning) , Egg/Fry	36% of days >61°F (Medium), 99.6% of days >53.5°F (Aug – Oct.) (Large).	5-7% of years	Water Temperature	 Reduced reproductive success, Reduced survival probability

2.5.2.3.3.1.3 CCV Steelhead Exposure, Response, and Risk

By the start of Summer Cold Water Pool Management, juvenile CCV steelhead will have started their migration out of the upper Sacramento River and tributaries with about 10 percent of juveniles having already passed RBDD by May 15 (University of Washington Columbia Basin Research 2019). The remaining 90 percent of juvenile CCV steelhead still in the upper Sacramento River would experience the conditions upstream of RBDD associated with the early temperature management season. By July, some adult CCV steelhead will have passed upstream of the RBDD with peak migration in September and October (McEwan 2001). There is limited information regarding CCV steelhead spawning locations in the Sacramento River, but since

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CCV steelhead spawning and eggs/alevin incubation occurs from November through April, effects to eggs are not considered under the effects of Summer Cold Water Pool Management.

Tier 1

As described for winter-run Chinook salmon, Reclamation would determine that Tier 1 operations apply as an initial early season target in approximately 68 percent of years based on the CalSimII modeling. HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 1 years, the threshold temperature of 61°F 7DADM for juvenile rearing, when converted to DAT, is exceeded in 23 percent of days from May 15 – October 31. For adult CCV steelhead migration, the threshold of 68°F is not exceeded during Tier 1 at RBDD during this period in Tier 1 years.

Tier 2

As described for winter-run Chinook salmon, Reclamation would determine that Tier 2 operations apply as an initial early season target in approximately 17 percent of years. HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 2 years, the threshold temperature of 61°F 7DADM for juvenile rearing, when converted to DAT, is exceeded at RBDD in 35 percent of days from May 15 – October 31. For returning adult CCV steelhead, the migration temperature threshold of 68°F is not exceeded at RBDD in Tier 2 years during this period.

Tier 3

As described for winter-run Chinook salmon, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately 7 percent of years. HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 3 years, the threshold temperature for of 61°F for juvenile rearing, when converted to DAT, is exceeded at the RBDD in 65 percent of days from May 15 – October 31. However, for returning adult CCV steelhead, the migration temperature threshold of 68°F would be exceeded in about 1 percent of days at RBDD during this period.

Tier 4

As described for winter-run Chinook salmon, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately 7 percent of years. The HEC-5Q modeling of the PA indicates that during the temperature management seasons of Tier 4 years, the threshold temperature of 61°F for juvenile rearing, when converted to DAT, would be exceeded at the RBDD in about 77 percent of days from May 15 – October 31. For returning adult CCV steelhead, the migration temperature threshold of 68°F would be exceeded at RBDD in less than 15 percent of days May 15 – October 31.

Temperature exceedances above the 61°F 7DADM EPA Region 10 threshold for juvenile CCV steelhead rearing could cause a competitive disadvantage with other fish, elevated disease rates and even death (*Water Temperatures*). For returning adult CCV steelhead, the migration temperature threshold of 68°F would be exceeded in less than 15 percent of days at RBDD during this period.

Effects of this component of the PA on CCV steelhead are condensed and summarized in Table 2.5.2-16.

Table 2.5.2-16 Summary Exposure, Risk, Response table for steelhead life-stages affected by stressors of Summer Cold Water Pool Management.

Tier	Life-stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
1	Juvenile	12% of days >61°F at RBDD (Medium)	45-68% of years	Water Temperature	Reduced lifetime reproductive success
2	Juvenile	20% of days > 61°F at RBDD (Medium)	17-35% of years	Water Temperature	Reduced lifetime reproductive success
3	Adult (migration) , Juvenile	1% of days > 68°F at RBDD (Minor) 44% of days > 61°F at RBDD (Medium)	7-15% of years	Water Temperature	Reduced reproductive success, Reduced lifetime reproductive success
4	Adult (migration) , Juvenile	15% of days > 68°F at RBDD (Medium) 59% of days > 61°F at RBDD (Large)	5-7% of years	Water Temperature	Reduced reproductive success, Reduced lifetime reproductive success

2.5.2.3.3.1.4 Green Sturgeon Exposure, Response, and Risk

The timing of Summer Cold Water Pool Management is such that it coincides with the peak of egg, larval and juvenile green sturgeon presence in the upper Sacramento River. Occurring from April to July, green sturgeon spawning in the Sacramento River extends from Cottonwood Creek just downstream of Balls Ferry to Hamilton City (Poytress et al. 2015).

Tier 1

As described for winter-run Chinook salmon, Reclamation would determine that Tier 1 operations apply as an initial early season target in approximately 68 percent of years based on

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the CalSimII modeling. Tier 1 operations are not expected to have a lethal effect on sDPS of green sturgeon eggs based on the HEC-5Q modeling of the PA which indicates that during Tier 1 years, the threshold temperature of lethal effect (71.5°F) is not exceeded at Hamilton City from May 15 – October 31. Sublethal effects would be expected in Tier 1 years; 31 percent of Tier 1 days exceed the threshold of 63.5°F at Hamilton City from May 15 – October 31.

Tier 2

As described for winter-run Chinook salmon, Reclamation would determine that Tier 2 operations apply as an initial early season target in approximately 17 percent of years. HEC5Q modeling of the PA indicate that during Tier 2 years, the threshold temperature of 71.5°F for egg mortality is not likely to be exceeded at Hamilton City during May 15 – October 31. Sublethal effects would be expected in Tier 2 years; 42 percent of Tier 2 days exceed the threshold of 63.5°F at Hamilton City from May 15 – October 31.

Tier 3

As described for winter-run Chinook salmon, Reclamation would determine that Tier 3 operations apply as an initial early season target in approximately 7 percent of years. HEC-5Q modeling of the PA indicate that during Tier 3 years, the threshold temperature of 71.5°F for egg mortality is exceeded in less than 1 percent of days at Hamilton City during May 15 – October 31. Sublethal effects are expected in Tier 3 years; 67 percent of Tier 3 days exceed the threshold of 63.5°F at Hamilton City from May 15 – October 31.

Tier 4

As described for winter-run Chinook salmon, Reclamation would determine that Tier 4 operations apply as an initial early season target in approximately 7 percent of years. HEC-5Q modeling of the PA indicate that the threshold temperature of 71.5°F for egg mortality is exceeded in 8 percent of Tier 4 days at Hamilton City from May 15 – October 31. Sublethal effects are expected in Tier 4 years; 74 percent of Tier 4 days exceed the threshold of 63.5°F at Hamilton City during May 15 – October 31.

Based on the temperature thresholds of the early life stages of this species and the predicted range of water temperatures in the upper Sacramento River during the temperature management season, the PA would be expected to negatively affect the growth, or survival of sDPS green sturgeon eggs and alevin (*Altered Water Temperature* stressor).

Effects of this component of the PA on green sturgeon are condensed and summarized in Table 2.5.2-17.

Table 2.5.2-17. Summary Exposure, Risk, Response table for green sturgeon life-stages affected by stressors of Summer Cold Water Pool Management.

Tier	Life-stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)			
1 Adult (spawning), Egg, Larval	31% of days >63.5°F at Hamilton City (Medium)	45-68% of years	Water Temperature	Reduced reproductive success				
2	Adult (spawning), Egg, Larval	42% of days >63.5°F at Hamilton City (Medium)	17-35% of years	Water Temperature	Reduced reproductive success			
3	Adult (spawning), Egg, Larval	67% of days >63.5°F at Hamilton City (Medium),	7-15% of years	Water Temperature	Reduced reproductive success			
4	Adult (spawning), Egg, Larval	8% of days >71.5°F (Small) 74% of days >63.5°F at Hamilton City (Medium)	5-7% of years	Water Temperature	Reduced reproductive success Reduced survival probabili			

2.5.2.3.4 Shasta Fall Operations

Fall (October-November) operations are dominated by temperature control and the provision of adequate fish spawning habitat. By late fall, the remaining cold water pool in Shasta Reservoir is usually limited. This forces consideration of the operational tradeoffs of maintaining high flows in early fall; summer and fall spawning fish may construct redds at the edge of the river where there is an increased likelihood of dewatering when flows are reduced. However, Reclamation is limited in its ability to reduce releases and build storage because early fall Sacramento River releases are still required to meet both the significant instream diversion demands between Keswick Dam and Wilkins Slough and SWRCB Delta requirements. For some actions, Reclamation may reduce releases, if it has that authority. This necessitates maintaining higher releases to support the instream demands until they decrease later in the season. After instream

demands decrease, Reclamation's objective is to decrease Keswick releases to a lower level in order to conserve storage.

2.5.2.3.4.1 Fall and Winter Refill and Redd Maintenance

As part of Shasta fall operations, Reclamation proposes to rebuild reservoir storage and cold water pool for the subsequent year by limiting the number of years that high fall releases are maintained. Maintaining releases to keep late-spawning winter-run Chinook salmon redds underwater may draw down storage necessary for temperature management in the subsequent year. Reclamation proposes to consider these competing needs with a risk analysis as described in their March 20, 2019, amended text:

"Reclamation will minimize effects with a risk analysis of the remaining winter-run Chinook salmon redds, the probability of sufficient cold water in a subsequent year, and a conservative distribution and timing of subsequent winter-run Chinook salmon redds. If the combined productivity of the remaining redds plus a conservative scenario for the following year is less than the productivity of maintaining releases, Reclamation will reduce releases to rebuild storage. The conservative scenario for the following year would include a 75 percent (dry) hydrology; 75 percent (warm) climate; a median distribution for the timing of redds, and the ability to remain within Tier 3 or higher (colder) Tiers."

If, based on the above risk analysis, Reclamation determines releases need to be reduced to rebuild storage, targets for winter base flows (December 1 through end of February) from Keswick would be determined in October and would be based on the previous month's Shasta Reservoir end of September storage projection. The October and November release targets would be determined according to BA Table 4-9 and revised to improve refill capabilities for Shasta Reservoir to build cold water pool for the following year.

Based on Reclamation's description of their risk analysis and the Fall and Winter Refill and Redd Maintenance PA component, NMFS is not able to determine how often October and November flows would need to be reduced to build storage, or how the effects to species will be considered. Without further clarification, NMFS assumes that the Shasta EOS and fall flows provided by the CalSimII model results accurately capture the results of the risk analysis and operational criteria. The likelihood of Reclamation implementing a particular release schedule is reflected in the proportion of years that Shasta end of September storage is less than or equal to 2.2 MAF. For the PA, CalSimII modeling indicates that Shasta end of September storage is less than 2.2 MAF in 20 percent of years.

Based on the PA, in years with the lowest Shasta storage at the end of September, Reclamation is expected to reduce flows to the greatest extent in the fall, winter, and spring to build storage. However, this action likely has a negative effect on downstream migration of juvenile salmonids. A recent assessment of mark-recapture survival models in the Sacramento mainstem revealed that of the numerous mortality factors considered, spanning multiple spatial scales, flow correlated most strongly with out-migration success (Iglesias et al. 2017). This assessment focused on hatchery-origin Chinook salmon, but it provides additional evidence that flow is one of the most important factors affecting overall survival of Chinook salmon in the Central Valley (Kjelson and Brandes 1989, Zeug et al. 2014, Michel et al. 2015). Likewise, comparison of 2015 and 2016 tagging data that included both CV spring-run Chinook salmon and fall-run Chinook salmon showed faster migration times and higher survival correlated to the higher flow

conditions in 2016 (Cordoleani et al. 2018). Overall, juvenile mortality during out-migration to the ocean is considered a critical phase to overall population dynamics (Williams 2006), and recent evidence suggests that winter-run Chinook salmon outmigration survival, and the conditions that affect it, are the primary drivers of smolt-to-adult ratio (SAR) dynamics (Michel 2018). Recent conditions in the mainstem Sacramento are such that a review of coded wire tag recovery data for winter-run, late-fall-run, and fall-run Chinook salmon showed annual SAR estimates of less than 1 percent. For winter-run Chinook salmon, the mean SAR from 1999 to 2012 was 0.64 (standard error of 0.18), well below the Columbia River Basin Fish and Wildlife Program suggested minimum of 2 percent SAR required for population survival and 4 percent for population recovery for Upper Columbia River and Snake River Chinook salmon populations (Michel 2018). Therefore, while reducing reservoir releases helps build storage for the following temperature management season, doing so also has a negative effect on downstream migration and survival. The resultant fall and winter flows for the PA are expected to be lower than what those of current operations, exacerbating winter-run Chinook salmon SAR, estimates of which are already below population survival and recovery benchmarks under baseline conditions.

Effects of this component of the PA on species are summarized in Table 2.5.2-18.

Table 2.5.2-18. Summary Exposure, Risk, Response table for species and life-stages affected by stressors of Fall and Winter Refill and Redd Maintenance.

Species	Life- stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
Winter- run Chinook salmon	Juveniles	<50% of population (Medium)	20% of years	 Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function 	Reduced survival probability
CV spring- run Chinook salmon	Redds	All (Large)	20% of years	 Spawning Habitat Availability Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function 	Reduced survival probability
CCV steelhead	Adults (migratio n, spawning), Redds	All (Large)	20% of years	 Spawning Habitat Availability Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function 	Reduced reproductive success Reduced survival probability (re:

Species	Life- stage	Exposure	Risk	Stressor	Response to Exposure and Risk as Expected Change in Fitness (Method Used)
					dewatering, stranding)
sDPS green sturgeon	NA	NA	NA	NA	NA

2.5.2.3.4.1.1 Winter-Run Chinook Salmon Exposure, Response, and Risk

Before the end of October, most winter-run Chinook salmon fry will have emerged from their redds and about half of the year's cohort of juveniles will have migrated past RBDD. Rotary screw trap data from the last 10 years show that more than 50 percent of a brood year's cohort will have yet to migrate past RBDD by October 1 (University of Washington Columbia Basin Research 2019). The species response to the conditions associated with Fall and Winter Refill and Redd Maintenance would be related to the *Flow Conditions* stressor which include possible stranding, poorer feeding conditions, increased competition and predation related to less floodplain and side-channel habitat, and reduced emigration flows.

The stranding risk associated with changes in operations is dependent on the physical attributes of the habitat and the magnitude of the change in flow. Flows during the egg incubation and initial juvenile rearing period (August to September) average approximately 8,000 cfs downstream of Keswick Dam; a stranding risk to juveniles exists when flows are reduced. The greatest risk posed by the operations proposed in the PA would occur when November flows are reduced to 3,250 cfs. For the PA, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 MAF in about 20 percent of years, and therefore in those years it is expected that October and November flows would be reduced to 3,250 cfs (ROC on LTO BA Appendix D Table 3-2). Similar to effects to winter-run Chinook salmon for the Winter Minimum Flows component of the PA, juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. For purposes of the analysis in Section 2.7 Integration and Synthesis of the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts, the risk of flow fluctuations in the river reaches below Keswick Dam that can strand winter-run Chinook salmon would continue. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. NMFS expects that stranding of at least a small proportion of winter-run juveniles will continue with PA implementation that will adversely affect exposed individuals.

With relation to the stressors Loss of Riparian Habitat and Instream Cover and Loss of Natural River Morphology and Function, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can

reduce accessibility to habitat that may support successful outmigration survival by providing rearing areas, refuge, or increased food availability.

2.5.2.3.4.1.2 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

By mid-October, close to 100 percent of CV spring-run Chinook salmon will have completed spawning in the upper reaches of the Sacramento River (Vogel and Marine 1991). The greatest risk posed by operations from October to November would occur in approximately 20 percent of years when Shasta end of September storage is expected to be less than or equal to 2.2 MAF. The species response to fall flows that are reduced to 3,250 cfs in the upper Sacramento River would include redd dewatering, stranding, poorer feeding conditions, increased competition and predation related to less floodplain and side-channel habitat and reduced emigration flows (*Flow Conditions*).

The dewatering risk associated with changes in operations is dependent on the physical attributes of the habitat and the magnitude of the change in flow. Flows during the CV spring-run Chinook salmon spawning period (August to October) average approximately 8,000 cfs downstream of Keswick Dam; a dewatering risk to CV spring-run Chinook salmon redds exists when flows are reduced. The greatest risk posed by the operations proposed in the PA would occur when November flows are reduced to 3,250 cfs. For the PA, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 MAF in about 20 percent of years; therefore in those years it is expected that October and November flows would be reduced to 3,250 cfs (ROC on LTO BA Appendix D Table 3-2).

Similar to effects to winter-run Chinook salmon, juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. For purposes of the analysis in Section 2.7 Integration and Synthesis of the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts, the risk of flow fluctuations in the river reaches below Keswick Dam that can strand CV spring-run Chinook salmon would continue. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. NMFS expects that stranding of at least a small proportion of CV spring-run Chinook salmon juveniles will continue with PA implementation that will adversely affect exposed individuals. With regard to CV spring-run Chinook salmon redds, the USFWS (2006) flow fluctuation and redd dewatering relationship, indicates that a flow reduction from an average spawning flow of about 8,000 cfs to 3,250 cfs would be expected to dewater about 33 to 42 percent of Chinook salmon redds (depending on whether the ACID Dam boards are out or in). Likewise, flow reductions from 8,000 cfs spawning flows to 4,000, 4,500 and 5,000 cfs would be expected to dewater about 24 to 29 percent, 18 to 22 percent and 12 to 15 percent of Chinook salmon redds, respectively. The species response to fall flows of 3,250 cfs, in the upper Sacramento River would include dewatering, which could lead to increased mortality.

With relation to the stressors Loss of Riparian Habitat and Instream Cover and Loss of Natural River Morphology and Function, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can

reduce accessibility to habitat that may support successful outmigration survival by providing rearing areas, refuge, or increased food availability.

2.5.2.3.4.1.3 CCV Steelhead Exposure, Response, and Risk

CCV steelhead express a diverse array of life-history strategies including both anadromous and resident (i.e., rainbow trout) life histories. Anadromous and resident life histories can be adopted by individuals from the same sibling cohort, making determinations regarding run timing difficult. During the October to November timing of operations for the Fall and Winter Refill and Redd Maintenance PA component, the majority of adult CCV steelhead are migrating past RBDD (McEwan 2001). The greatest risk posed by these seasonal operations would occur during the 20 percent of years when minimum Keswick flows would be 3,250 cfs. The species response to fall flows of 3,250 cfs in the upper Sacramento River would include stranding, increased competition and reduced spawning habitat availability related to less floodplain and side-channel habitat (*Flow Conditions*).

The dewatering risk associated with changes in operations is dependent on the physical attributes of the habitat and the magnitude of the change in flow. Flows during the steelhead spawning period (August to October) average approximately 8,000 cfs downstream of Keswick Dam; a dewatering risk to steelhead redds exists when flows are reduced. The greatest risk posed by the operations proposed in the PA would occur when November flows are reduced to 3,250 cfs. For the PA, CalSimII modeling indicates that end of September storage is less than or equal to 2.2 MAF in about 20 percent of years; therefore in those years it is expected that October and November flows would be reduced to 3,250 cfs (ROC on LTO BA Appendix D Table 3-2). Similar to effects to winter-run Chinook salmon, juvenile stranding generally results from reductions in flow that occur over short periods of time, and analytical planning tools cannot predict with certainty the level of effect of possible stranding on fish. For purposes of the analysis in Section 2.7 Integration and Synthesis of the combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts, the risk of flow fluctuations in the river reaches below Keswick Dam that can strand steelhead would continue. The potential for juvenile stranding would also persist as operations continue to target lower reservoir releases in the fall and winter to maximize storage. NMFS expects that stranding of at least a small proportion of CCV steelhead juveniles will continue with PA implementation that will adversely affect exposed individuals.

With relation to the stressors Loss of Riparian Habitat and Instream Cover and Loss of Natural River Morphology and Function, NMFS considers that the managed changes in the hydrograph can reduce access to riparian habitat and instream cover both in the immediate area of releases and further downstream (e.g., less frequent inundation of side channels). These changes can reduce accessibility to habitat that may support successful outmigration survival by providing rearing areas, refuge, or increased food availability.

2.5.2.3.4.1.4 sDPS Green Sturgeon Exposure, Response, and Risk

sDPS green sturgeon life history timing is such that it is unlikely that sDPS green sturgeon will be present in the upper Sacramento River when Reclamation is managing flows to Fall and Winter Refill and Redd Maintenance. Adult sDPS green sturgeon migrate up river in March to early April, and spawn from April through July with the median spawning May (Poytress et al. 2015).

2.5.2.3.4.2 Rice Decomposition Smoothing

Water demand changes in the upper Sacramento River throughout the fall could result in some early fall-run Chinook salmon redds being dewatered. Reclamation proposes to meet a shifting demand as upstream Sacramento Valley CVP contractors and the Sacramento River Settlement Contractors synchronize their diversions to reduce demands for peak rice decomposition. NMFS notes this action is also part of the four action components of the PA identified on May 22, 2019, that Reclamation intends to implement to contribute to increased spring Shasta storage levels compared to the COS and current operations.

Based on the description of the PA component and the assessment of its effects in the BA, NMFS understands that this action has the potential to build storage, which may have a beneficial effect on the subsequent cold water pool. However, increased coordination between Reclamation and the water contractors that considers the spawning and rearing needs of species would likely provide increased awareness, if not protection, for those species. As part of the Fall and Winter Refill and Redd Maintenance PA component operations described in Section 2.5.2.3.4.1, Reclamation would assess the downstream water demands of the upstream CVP contractors and the Sacramento River Settlement Contractors. Coordinated diversions in late October and early November could provide increased reliability that target flows would be met according to the Fall and Winter Refill and Redd Maintenance operations and that Reclamation would be able to build storage during this period. NMFS assumes that the minimum flows identified in the PA for this season would be achieved, and this action component would, therefore, provide greater certainty that Reclamation would be able to reduce releases and build storage according to the Fall and Winter Refill and Redd Maintenance action component. The effects of this action are included in the analysis of Shasta Fall Operations.

2.5.2.4 Operation of a Shasta Dam Raise

Under a separate ESA consultation for construction, Reclamation proposes to enlarge Shasta Dam and Reservoir by raising the dam crest 18.5 feet. The PA states that the additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet water temperature objectives and habitat requirements for salmonids during drought years and increase water supply reliability; however, no new operational criteria are proposed.

The PA description of operational criteria with the Shasta Dam Raise will be the same as operational criteria for the current dam and integrated CVP/SWP operations. Reclamation has advised NMFS that the BA analyses suffice for purposes of consultation. There are no operational scenarios in the BA to evaluate to confirm beneficial or adverse effects of a raised Shasta Dam and NMFS therefore cannot further evaluate the Shasta Dam raise in this Opinion. However, we note that if operations with a larger dam do result in either modifications to Shasta or system-wide operations (as modeled in CalSimII) or effects to the species that are beyond the range analyzed in this Opinion (for example, changes in spring flows to build new storage), reinitiation of this Opinion would be triggered.

2.5.2.5 Conservation Measures

Conservation measures are included in the PA with the intent of avoiding and minimizing or compensating for CVP and SWP project effects, including take, on listed species.

2.5.2.5.1 Cold Water Management Tools

Reclamation has proposed to explore additional non-flow actions intended to extend the cold water pool. However, during a consultation meeting between Reclamation and NMFS on June 25, 2019, Reclamation indicated that Reclamation does not commit to implementing any of these PA components, but rather, Reclamation would consider the benefits of each as possible measures to be taken to improve cold water pool availability. These possible PA components and an assessment of their effect, to the extent possible, are included below.

2.5.2.5.1.1 Battle Creek Restoration

As discussed in the Environmental Baseline section of this Opinion, pursuant to the RPA in the NMFS 2009 Opinion, Reclamation and DWR shall provide improved instream flow releases and safe fish passage to prime salmon and steelhead habitat on Battle Creek for winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. This is also a Priority 1 NMFS recovery action (National Marine Fisheries Service 2014b). The project has been supported with Federal, State and private funding.

As of 2019, implementation of the Battle Creek Salmon and Steelhead Restoration Project has completed construction of phase one (of two), which included removal of one fish passage barrier (a dam) and construction of NMFS-approved fish screens and ladders at the two remaining dams on North Fork Battle Creek. Phase two of the project has completed planning, and is currently in design phase. Although implementation has been significantly delayed, NMFS expects benefits to listed salmonids once completed.

If Reclamation determines that this PA component would be a cost-effective means to extend the availability of Shasta cold water pool, Reclamation proposes that it could continue and/or accelerate implementation of the Battle Creek Salmon and Steelhead Restoration Project. This project is intended to reestablish approximately 42 miles of prime salmon and Steelhead habitat on Battle Creek, and an additional 6 miles on its tributaries. While lacking specificity, NMFS notes overall beneficial effects of this accelerated action and intends to engage with Reclamation on specific approaches in order to provide credit for this action. Winter-run Chinook salmon are currently limited to a single population that spawns in an approximately 10-mile stretch of the Sacramento River, but they are being reintroduced to Battle Creek (around 200,000 juveniles were released in Battle Creek in 2018), and any returning adults from the release would benefit from the restoration efforts. NMFS notes that the PA is not intended to bear the responsibility of establishing viable populations, which are required for recovery of the species. However, we offer that an additional population of winter-run Chinook salmon in Battle Creek could provide strategic temperature compliance flexibility in the Sacramento River, which could alleviate constraints on Shasta operations for species protection in some conditions.

The effects of parts of this project are included in the baseline conditions of the analysis for this Opinion. Because Reclamation is not committing to the action component and the ROC on LTO PA does not include specificity in resources, timing, or defined actions by which the project would be accelerated, benefits besides those considered in the baseline condition are included in this analysis of effects at the framework level. Any influence Reclamation pursues to accelerate implementation of the restoration project is expected to result in earlier access to preferred habitat for listed salmonids.

2.5.2.5.1.2 Lower Intakes near Wilkins Slough

Due to temperature requirements, Sacramento River flows at or near Wilkins Slough have decreased below the 5,000 cfs minimum navigational flow deemed by Congress. As many of the fish screens at diversions in this region were designed to operate at no less than the 5,000 cfs minimum flowrate, they may not function properly at the lower flows and, therefore, may not meet state and federal fish screening requirements during the lower flows (U.S. Bureau of Reclamation 2019) or may cavitate and damage intake pumps. This could result in take of state and federally protected species that use this section of the river. If Reclamation determines that this PA component would be a cost-effective means to extend the availability of Shasta cold water pool Reclamation would provide grants to water users within this area to install new diversions and screens that would operate at lower flows. Reclamation expects that if this action were implemented, it would provide greater flexibility in managing Sacramento River flows and temperatures for both water users and wildlife, including listed salmonids (U.S. Bureau of Reclamation 2019). However, because the ROC on LTO PA does not include specificity in timing or defined actions, any benefits of this action are included in the analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of the project is expected to result in earlier benefits for listed salmonids.

Given the framework-level programmatic nature of the Lower Intakes near Wilkins Slough action component, where further commitment and collaborative planning is necessary to identify effects and quantify a level of benefits and incidental take, but where it is still possible to estimate a general level of impact qualitatively, NMFS applies the following assumptions regarding the potential species exposure, response, and risk:

- If Relamation were to implement this PA component, construction related to the Lower Intakes near Wilkins Slough PA component would be done in a manner consistent with best management practices and applicable in-water work windows, such that exposure to construction-related impacts would be minimized to the greatest extent practicable. The frequency with which species would be exposed to the construction related impacts remains uncertain as it is unknown or difficult to predict the number, timing, and location of water diversions requiring fish screen installation or remediation. NMFS assumes that a small proportion of fish may be exposed to construction-related effects such as increased turbidity, pile driving effects associated with installation of coffer dams, flow alteration around a construction site, and effects associated with handling and transport of fish isolated and rescued from behind coffer dams.
- If Relamation were to implement this PA component, there would be a long-term benefit associated with improving the function of existing fish screens or installing new fish screens near Wilkins Slough. This benefit would be assumed to affect juvenile fish in particular as they are most susceptible to being entrained into unscreened or poorly screened diversions. The frequency of exposure would be assumed to be high because installation or repair of fish screens would result in a semi-permanent reduction in the otherwise lethal effect of entrainment and impingement.

2.5.2.5.1.3 Shasta Temperature Control Device Improvements

If Reclamation determines that this PA component would be a cost-effective means to extend the availability of Shasta cold water pool, Reclamation would study the feasibility of infrastructure

improvements to enhance TCD performance, including reducing the leakage of warm water into the structure. However, Reclamation is not committing to implementing this PA component, but rather would consider the benefits relative to other such tools identified in Section 2.5.2.5.1. Depending upon the outcome of the proposed Shasta Dam raise, the TCD would be either modified or replaced by Reclamation, as informed by updated modeling. Depending on the size of the raise, the existing TCD structure would be retrofitted to account for additional dam height and to reduce leakage of warm water into the structure, but no new structure would be needed. However, modifications to, or replacement of, the existing structure are more likely to be necessary for increasingly higher dam raises. The authority for this action is 3406(b)(6). While the resources are provided for this action and Reclamation expects that if selected for implementation that this action would provide greater flexibility in managing Sacramento River flows and temperatures, the ROC on LTO PA does not commit to its implementation nor does it include specificity in timing, performance metrics, or defined actions. Therefore any benefits of this action are included in this analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of the improvements is expected to result in earlier benefits for listed salmonids.

2.5.2.5.2 Spawning and Rearing Habitat Restoration

2.5.2.5.2.1 Spawning Gravel Injection

Reclamation proposes to create additional spawning habitat by injecting 40–55 tons of gravel into the Sacramento River by 2030, using the following sites: Salt Creek Gravel Injection Site, Keswick Dam Gravel Injection Site, South Shea Levee, Shea Levee, and Tobiasson Island Side Channel.

The effects of this project are included in the baseline conditions of the analysis for this Opinion. Because the ROC on LTO PA does not include specificity in resources, timing, or defined actions by which this project would occur, any benefits of this action besides those included in the baseline are included in this analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of the restoration is expected to result in earlier benefits for habitat access listed salmonids.

Given the framework-level programmatic nature of the Spawning Gravel Injection action component, as a result of Reclamation's continued support of this programmatic action, NMFS applies the following assumptions regarding species exposure, response, and risk:

 Expected long-term benefit associated with increasing the quantity and quality of spawning substrate in the upper Sacramento River. This benefit is expected to affect adult fish in particular as they return to spawn. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in spawning habitat availability.

2.5.2.5.2.2 Side Channel Habitat Restoration

Reclamation and the Sacramento River Settlement Contractors propose to create 40–60 acres of side channel habitat at approximately 10 sites in Shasta and Tehama County by 2030, including Cypress Avenue, Shea Island, Anderson River Park; South Sand Slough; Rancheria Island; Tobiasson Side Channel; and Turtle Bay.

The effects of this project are included in the baseline conditions of the analysis for this Opinion. Because the ROC on LTO PA does not include specificity in resources, timing, or defined actions by which this project would occur, any benefits of this action besides those included in the baseline are included in this analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of the restoration is expected to result in earlier access of beneficial habitat for listed salmonids.

Given the framework-level programmatic nature of the Side Channel Habitat Restoration action component, as a result of Reclamation's continued support of this programmatic action, NMFS applies the following assumptions regarding species exposure, response, and risk:

 Expected long-term benefit associated with increasing the quantity and access to quality side channel rearing habitat in the upper and middle Sacramento River. This benefit is expected to affect rearing and migrating juvenile fish. The frequency of exposure is assumed to be high because completed restoration activities would result in a semipermanent increase in rearing habitat availability.

2.5.2.5.2.3 Small Screen Program

As part of adaptive management, Reclamation and DWR propose to continue to work within existing authorities (e.g., Anadromous Fish Screen Program) to screen small diversions throughout Central Valley CVP/SWP streams and the Bay-Delta.

The beneficial effects of previous actions under this program (minimizing entrainment at a specific diversion) are included in the baseline conditions of the analysis for this Opinion. Because the ROC on LTO PA does not include specificity in resources, timing, or defined actions by which this program would occur, any benefits of new actions are included in this analysis of effects in this Opinion at the framework level. Any influence Reclamation pursues to accelerate implementation of this program is expected to result in earlier benefits for listed salmonids.

Given the framework-level programmatic nature of the Small Screen Program action component, where further collaborative planning is necessary to identify effects and quantify a level of benefits and incidental take, but where it is still possible to estimate a general level of impact qualitatively, NMFS applies the following assumptions regarding species exposure, response, and risk:

- That construction related to the Small Screen Program action component will be consistent with best management practices and applicable in-water work windows, which would minimize exposure to construction-related impacts to the greatest extent practicable. The frequency with which species would be exposed to the construction related impacts remains uncertain as it is unknown or difficult to predict the number, timing, and location of water diversions requiring fish screen installation or remediation. NMFS assumes that a small proportion of fish may be exposed to construction-related effects such as increased turbidity, pile driving effects associated with installation of coffer dams, flow alteration around a construction site, and effects associated with handling and transport of fish isolated and rescued from behind coffer dams.
- That there is a long-term benefit associated with improving the function of existing fish screens or installing new fish screens in the Sacramento River. This benefit is assumed to

affect juvenile fish in particular as they are most susceptible to being entrained into unscreened or poorly screened diversions. The frequency of exposure is assumed to be high since installation or repair of fish screens would result in a semi-permanent reduction in the otherwise lethal effect of entrainment and impingement.

2.5.2.5.3 Intervention Measures

In the March forecast (mid-March), if the forecasted Shasta Reservoir total storage is projected to be below 2.5 MAF at the end of May (based on the 90 percent exceedance outlook), Reclamation would initiate discussions with USFWS and NMFS on potential intervention measures in preparation for the low storage condition to continue into April and May. If total storage is less than 2.5 MAF at the beginning of May, or if Reclamation cannot meet a daily average temperature 56°F at CCR, Reclamation will attempt to operate to a less than optimal temperature target and period that is determined in real-time. Reclamation proposed to develop this alternate target with technical assistance from NMFS and USFWS. In addition, Reclamation proposes to implement intervention measures during these years (e.g., increasing hatchery intake, adult rescue, and juvenile trap and haul, as described below). These intervention measures would be considered by Reclamation only in the years identified as Tier 4 years of Summer Cold Water Pool Management. As such, the intervention measures are intended to minimize or mitigate the effects of conditions and operations associated with the Tier 4 years.

2.5.2.5.3.1 LSNFH Production (Intervention)

In a Tier 4 year, Reclamation proposes to increase production of winter-run Chinook salmon at the LSNFH. As part of the increased production, Reclamation would consider New Zealand or Great Lake winter-run Chinook salmon stock for augmenting conservation hatchery stock to improve heterozygosity.

Effects of increased hatchery production will depend on complex interactions between hatchery and natural-origin fish and their environment. The short-term benefit of expanded LSNFH production is that it would provide alternative (artificial) rearing and spawning habitat when the in-river environmental conditions are not suitable for egg-fry life stages. Because this PA component is only proposed for Tier 4 years, the intent is for it to offset, in part, the effects of Tier 4 operations described in Section 2.5.2.3.3.1.1 (Winter-Run Chinook Salmon Exposure, Response, and Risk).

A potential long-term consequence of expanding numbers of hatchery fish is an increase of hatchery origin fish on in-river spawning grounds. In the development of LSNFH's HGMP considerable effort has been made to minimize any adverse genetic or ecological effects to the natural population (U.S. Fish and Wildlife Service 2016b). For example, winter-run Chinook salmon are collected and spawned throughout the duration of run timing to maintain phenotypic and genetic variability. A factorial-type spawning scheme is used to increase the effective population size of hatchery-produced winter-run Chinook salmon. Phenotypic and genetic broodstock selection criteria are used to ensure that the potential for genetic bottlenecks do not occur in the hatchery. Further, limits have been established for the collection of natural-origin winter-run Chinook salmon broodstock; the annual limit for broodstock collection is 60 females and up to 120 males, totaling up to 180 adult natural-origin winter-run Chinook salmon. These

limits guard against removing too many fish from the naturally-spawning population and increase the effective population size of the hatchery component of the population.

In fact, increasing production at LSNFH is already considered as part of the hatchery's HGMP, where during emergencies, such as the extreme drought of 2014 and 2015, production of winterrun Chinook salmon may be increased above the standard production levels to partially mitigate for extremely poor environmental conditions. The temporary expansion of winter-run Chinook salmon propagation activities during the 2014-2015 was based on the anticipation of temperatures unfavorable for successful natural spawning in the Sacramento River. During those years when environmental conditions result in the need for increased hatchery production (limited to a maximum of 400 adult winter-run Chinook salmon for use as broodstock), broodstock collection targets are determined collaboratively by USFWS, NMFS, and CDFW. Factors such as expected adult escapement, expected environmental conditions, expected juvenile survival, and the number of tagged juveniles available for fishery assessments will be considered when determining whether program expansion is warranted (U.S. Fish and Wildlife Service 2016b).

Also, as described in the Section 2.4 Environmental Baseline section of this Opinion and in the ROC on LTO BA Appendix C, the USFWS has been engaged in efforts regarding LSNFH. During the drought in 2014 and 2015, and at the request of NMFS and CDFW, LSNFH increased production of winter-run Chinook salmon to compensate for expected high temperature-dependent mortality in the Sacramento River and re-instated the captive broodstock program. Reclamation also funded the rental of two commercial-size chillers to ensure adequate water temperatures for adult holding, egg incubation, and juvenile rearing. Those chillers were rented during the summer and fall and used on a just few occasions. Subsequently, Reclamation has funded a small permanent chiller to ensure temperatures for egg incubation only. Reclamation also supports USFWS efforts for coded-wire tagging, acoustic tagging, and associated monitoring of national fish hatchery-produced winter-run Chinook salmon under long-term operational funding agreements that have a long history of renewal.

NMFS anticipates that additional improvements will be necessary to support the proposed intervention measure, including securing an emergency or alternate water supply when Shasta and Keswick reservoirs reach elevations below the current penstock, acquiring water chillers to ensure that adequate water temperatures are provided during critical winter-run Chinook salmon life stages, acquiring more physical space to adequately rear increased production to help the population withstand the drought and to successfully operate the captive broodstock program, making modifications or improvements to Keswick Dam Fish Trap, making improvements to the water treatment facility, and possibly making modifications/improvements to the ACID fish trap. These improvements are described in detail in ROC on LTO BA Appendix C and generally summarized below:

Current ideas for improving water supply include: (1) replacing and upgrading valves, controllers, and alarms to ensure the water supply is more secure and staff are better able to respond to water alarms; and (2) connecting Penstock 5 (which is lower than the other penstocks) to the hatchery water system to allow greater flexibility to provide more cold water during low lake levels and during penstock

- maintenance outages. Replacing and upgrading valves, controllers, and alarms would improve biosecurity and efficiency at the hatchery under all conditions.
- Installing chillers at critical times during drought conditions for adult holding and juvenile rearing is essential to ensure that the increased demand can be met during drought years.
- In 2016, a multi-agency work team concluded LSNFH would need to expand by 8 to 10 circular tanks to raise an additional 350,000 fish if the hatchery were to engage in the same drought operations they did in the recent drought. Increasing the capacity of LSNFH would require expanding to the west side of the hatchery road, additional piping to that side of the property, and additional water.
- An investigation to to evaluate improvements to the fish trap and elevator to reduce the likelihood of injuring or killing fish during fish transfer. USFWS is planning to discuss the potential need for improvements with Reclamation, and if improvements are necessary, is confident that the agencies can identify the funds necessary to implement the improvements.
- The USFWS has recently begun to discuss the potential need for a drum screen to remove solids in the hatchery's effluent. The drum screen could allow the USFWS more flexibility in the use of medicated feed to prevent and treat disease.

With little description of this action component, how it may differ from the existing HGMP or how it may affect the species, there is insufficient information available to assess the effects, and how those may differ from effects analyzed in the HGMP, which is part of the baseline. In order to provide enough certainty regarding how and when the PA component would be implemented, and to assess its effects, the expanded production at LSNFH will need to be developed further. Generally, a commitment to assess and eventually incorporate the expanded production at LSNFH would be expected to have beneficial effects decreasing the potential negative effects of environmental conditions and water operations during a Tier 4 year, but additional facility improvements or expanded use of the captive broodstock program may be necessary to accommodate this Tier 4 action. NMFS is also uncertain of the viability of using of New Zealand or Great Lakes winter-run Chinook salmon stock for augmenting conservation hatchery stock to improve heterozygosity, and there are potential negative consequences to the species of introducing an outside stock. Additional science is necessary to begin consideration of those stocks. Uncertainty regarding the effects of the PA component could be addressed, and the mechanism for incorporating the PA component in to operations would be described and understood through implementation of this Collaborative Planning Action.

2.5.2.5.3.2 Adult Rescues (Intervention)

Reclamation proposes to trap and haul adult salmonids and sturgeon from Yolo and Sutter bypasses during droughts and after periods of bypass flooding, when flows from the bypasses are most likely to attract upstream migrating adults, and move them up the Sacramento River to spawning grounds. This trap and haul is in addition to weir fish passage projects that are part of the PA elsewhere. This could improve survival of the adults, leading to increased juvenile production in the following year and more flexibility with salvage. Because the ROC on LTO PA does not include details on these rescue actions (e.g., process for identifying the need, process for rescue and return, evaluation of return success or definition of performance metrics, definition of

reporting tasks), NMFS considers this a programmatic action. Effects are considered but exemption for take associated with this action is not provided in this Opinion.

2.5.2.5.3.3 Juvenile Trap and Haul (Intervention)

If Reclamation projects Tier 4 operations for an upcoming summer (i.e., less than 2.5 MAF of Shasta storage at the beginning of May), the PA includes that Reclamation will propose implementation of a downstream trap and haul strategy for the capture and transport of juvenile Chinook salmon and steelhead in the Sacramento River watershed. This is proposed for drought years when low flows and resulting high water temperatures are unsuitable for volitional downstream salmonid migration and survival. Reclamation proposes to place temporary juvenile collection weirs at key feasible locations downstream of spawning areas in the Sacramento River. Reclamation would transport collected fish to a safe release location or locations in the Delta upstream of Chipps Island. Juvenile trap and haul activities would occur from December 1 through May 31, consistent with the migration period for juvenile Chinook salmon and steelhead (National Marine Fisheries Service 2014a), depending on hydrologic conditions. In the event of high river flows or potential flooding, the fish weirs would be removed. The benefits of this component is uncertain, even for years of extremely low storage. Because the ROC on LTO PA does not include details on these trap and haul actions (e.g., process for identifying the need, process for trapping and return, evaluation of return success or definition of performance metrics, definition of reporting tasks), NMFS considers this a programmatic action. Exemption for take associated with this action is not provided in this Opinion.

2.5.2.6 Supplemental Analysis of June 14, 2019, Final PA

During consultation for this Opinion, discussions between NMFS and Reclamation resulted in revisions to the PA that were not captured in the February 5, 2019, BA that was used for the majority of the analysis in this Opinion. It was not possible to include these revisions in any modeling due to the White House memorandum that mandated issuance of final biological opinions within 135 days of January 31, 2019 (June 17, 2019, and subsequently extended to July 1, 2019). The effects description above (Section 2.5.2.1-2.5.2.5) was based on the modeling associated with the February 5, 2019 PA (Appendix A1, the original PA) and associated modeling that NMFS requested. The following subsection provides a supplemental effects analysis of the June 14, 2019 PA revisions reflected in the final PA (Appendix A3), including a discussion of whether and how the PA revisions modify the effects analyzed above.

Also during the consultation for this Opinion, the Sacramento River Settlement Contractors (SRSC) drafted for adoption a resolution that includes three key actions that are integrated into the February 5, 2019, description of the proposed action and analyzed in this Opinion (Appendix A3):

- 4. The SRSC intend to meet and confer with Reclamation, NMFS, and other appropriate agencies in connection with Reclamation's operational decision-making for Shasta Reservoir annual operations during drier water years when operational conditions are designated as Tier 3 and Tier 4 scenarios.
- 5. The SRSC intend to continue to participate in, and act as project champions for, similar types of future Recovery Program projects, subject to the availability of funding, regulatory approvals, and acceptable regulatory assurances.
- 6. The SRSC are committed to continue their active engagement and leadership in the

ongoing collaborative Sacramento River Science Partnership effort.

The actions described in the draft SRSC resolution are qualitatively factored into the analysis of this Opinion.

2.5.2.6.1 Revisions to the PA Relevant to the Shasta/Upper Sacramento Division

As a result of discussions, the Upper Sacramento River (Section 4.10.1) and Governance (Section 4.12) sections of the BA included notable changes and clarification (Appendix A3). These sections are noted in the discussion of each below.

2.5.2.6.1.1 Summer Cold Water Pool Management (BA Section 4.10.1.3.1)

Revisions to the Summer Cold Water Pool Management section of the BA (Section 4.10.1.3.1) include a description of the process for development of an annual temperature management plan, including use of conservative forecasts and NMFS participation through the SRTTG.

Compared to the previous analysis, this revision decreases the uncertainty of operations being able to stay within the determined Tier for the duration of the temperature management season. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which, due to limitations of the models, do not explicitly mimic the process of developing a temperature management plan by projecting stream temperatures through summer for various management scenarios – to be more accurate in characterizing the likelihood of maintaining the determined Tier of projected and expected operations. That is, given the commitment to develop a temperature management plan based on conservative meteorology, hydrology, and inflows, we consider it more likely that the operations will stay within the determined Tier throughout the season, which is what is reflected in the modeling and analysis.

We do not have quantitative support to indicate exactly how any results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management would change in response to this revision. However, we consider that the temperature management plan may reduce the likelihood of exceeding the temperature target, which is used in the characterization of exposure to increased temperatures in the previous analysis. Given the inability to quantify this reduction and NMFS' adherence to the principle of institutionalized caution, we still consider the results in Section 2.5.2.3.3.1 Summer Cold Water Pool Management as the best quantitative characterization of the exposure of the species to the stressor of increased water temperature and the risk based on the expected long-term proportion of years in each Tier type.

2.5.2.6.1.2 Commitment to Cold Water Management Tiers (BA Section 4.10.1.3.2)

The addition of the Commitment to Cold Water Management Tiers section of the final PA (Section 4.10.1.3.2) includes definition of commitments to the cold water management tier identified at the beginning of the temperature management season and actions required if a change in Tier is required.

Compared to the previous analysis, this revision decreases the uncertainty of operations moving to a different Cold Water Management Tier during the temperature management season. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which do not incorporate mid-season changes to a different Tier – to be a more accurate characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management will not change quantitatively, as this

commitment to maintaining the determined Tier and required actions upon changes in Tier do not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

The PA revisions include the action of chartering an independent panel in the case that Reclamation moves to a warmer Tier during the temperature management season. While this is greatly informative in increasing the understanding of what conditions or operations contributed to the need to change Tiers, it is a post-hoc evaluation that in and of itself does not afford additional protections to the species or alter the quantitative analysis already completed based on the modeling results. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management will not change quantitatively, as this evaluation of the need to change Tier does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

2.5.2.6.1.3 Upper Sacramento Performance Metrics (BA Section 4.10.1.3.3)

Revisions to the Cold Water Pool Management section of the final PA includes the addition of Section 4.10.1.3.3 Upper Sacramento Performance Metrics. The objective of these performance metrics is to ensure that the conditions that manifest as a result of operations within a tier reflect the modeled range, and show a tendency towards performing at least as well as the distribution produced by the simulation modeling of the PA. It includes tracking of both TDM and egg-to-fry survival over time with the objective of completing annual and multi-year hindcast evaluations of the ability to meet the survival objectives and of the expectation that hydrology will occur as identified by the probabilities in the modeling. The metrics also include identification of expected improvement of egg-to-fry survival from habitat restoration projects recently completed, currently underway, or proposed to be completed by year 2030 (the duration of the PA). The additions identify drought and dry year actions and annual reporting, along with hindcast analysis of survival to identify if results are within the central tendency of modeled and analyzed results. The text also describes the process for chartering independent reviews, including established timelines, triggers, and focus topics.

Compared to the previous analysis, this addition to the Cold Water Pool Management section contributes to increasing the certainty that the central tendency of the analyzed results is what the species will experience when these operations are implemented. That is, the analysis characterized exposure and risk based on the central statistics of modeled TDM for each Tier type and the long-term projected likelihood of occurrence of each year type. However, the TDM results included a broad range for each Tier due to the variability of conditions included in each Tier type. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which is based on the central tendency to capture the most likely conditions – to be a more accurate characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management will not change quantitatively, as this commitment to assess cold water management does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

2.5.2.6.1.4 Conservation Measures (BA Section 4.10.1.4.2)

Revisions to the Conservation Measures section of the final PA (Section 4.10.1.4.2) include introduction of measures to avoid and minimize or compensate for CVP and SWP project effects on species. The recent revisions have added measures related to Shasta reservoir temperature modeling, improvements to LSNFH, and actions required to protect winter-run Chinook salmon during and after high mortality years.

The Temperature Modeling Platform PA component that Reclamation is proposing to consider as a possible Cold Water Manamgment Tool would advance a tool that could provide a more accurate characterization of reservoir temperature conditions and contribute to more efficient use of available cold water pool, improved temperature conditions, and likely increased species protections. However, Reclamation is not committing to implementing this PA component, but rather would consider the benefits, as a cost-effective means to extend the availability of Shasta cold water pool, relative to other such tools identified in Section 2.5.2.5.1.

In addition, the final PA has added a conservation measure intended to protect the third cohort of winter-run Chinook salmon after two consecutive years of poor survival. This measure increases the likelihood that protections will be afforded to maximize the egg-to-fry survival of the year class immediately following two brood years of low egg-to-fry survival. This measure is intended to allow opportunities for actions to be implemented to protect species despite the probability of year types that may occur. While the PA modeling based on a historic 82-year sample set indicates a 68 percent likelihood that a year would be in Tier 1 operations, the complex dynamics of the historic hydrologic timeseries in California suggests that it is prudent to prepare for multiple years of drier-than-normal conditions, even if the summary statistics of conditions in the model period do not capture these sequential years of extended wet or extended dry periods.

Compared to the previous analysis, these revisions and additions to the conservation measures contribute to decreasing the uncertainty of the characterization of the volume of cold water pool available, and therefore the likelihood of achieving the target temperature of the determined cold water management Tier. This would be the case for the Temperature Modeling Platform, which if Reclamation determines that this PA component is a cost-effective means to extend Shasta cold water pool, it would be expected to improve the ability to predict summer operations by providing a more accurate characterization of cold water pool volume and reservoir temperature dynamics. However, the benefits of this measure are uncertain as Reclamation has only committed to consider it and those benefits will not be immediately realized, as the modeling would not be available for implementation.

Compared to the previous analysis, the addition of the conservation measure to protect the third cohort after two years of poor survival decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that because of any actions taken in this instance, the resulting mortality value would be in the middle range of the broad range that results from the modeling (e.g., 5-77 percent in Tier 3 years), especially after two consecutive years of low survival. With this change, we consider our previous analysis of the modeled outcomes of temperature management to still apply as a conservative characterization of projected and expected operations. Based on factoring in a 32 percent background (i.e., non-temperature dependent) mortality to the modeled temperature dependent mortality for each year, the 82-year modeled dataset includes three intervals in which this type of intervention may have

been warranted (1931-1934, 1976-1977, and 1991-1992). The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management could slightly over-represent a third year of high mortality, however, the results of the modeling would not notably change the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

2.5.2.6.1.5 Drought and Dry Year Actions (BA Section 4.12.5)

Revisions to the Governance section of the PA includes the addition of Section 4.12.5 Drought and Dry Year Actions to develop a toolkit of actions to be taken in drought conditions, and a process by which early warnings of drought conditions may allow for clear and swift development of a drought contingency plan.

Compared to the previous analysis, the addition of the drought and dry year actions decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that any actions taken in this instance would increase the likelihood that resulting mortality values would be minimized to the extent possible. With this change, we consider our previous analysis of the modeled outcomes of temperature management to still apply as a conservative characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management could slightly over-represent a high mortality event that could be prevented by this Drought and Dry Year Action; however, the results of the modeling would not notably change the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

2.5.2.6.1.6 Chartering of Independent Panels (BA Section 4.12.6) and Four Year Reviews (BA Section 4.12.7)

Revisions to the Governance section of the PA include the addition of Section 4.12.6 Chartering of Independent Panels and Section 4.12.7 Four-Year Reviews to charter reviews either at set dates or as triggered. The review topics are expected to include the Upper Sacramento Performance Metrics and associated topics in that section.

While the reviews will be greatly informative in increasing the understanding of effects of temperature conditions and operational decisions on species response, they are post-hoc evaluations that alone do not afford additional protections to the species or alter the quantitative analysis already completed based on the modeling results. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management will not change quantitatively, as this commitment to assessing the performance of the PA does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

2.5.2.6.1.7 SRSC Meet and Confer During Tier 3 and Tier 4 Scenarios

The commitment from the SRSC to meet and confer during Tier 3 and Tier 4 years, as requested, further decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that any actions taken would increase the likelihood that resulting mortality values would be minimized to the extent practicable, particularly for winter-run Chinook salmon. Additionally, delayed diversions for rice decomposition during the fall months

could provide increased reliability that target flows would be met according to the Fall and Winter Refill and Redd Maintenance operations for building storage and reducing the effects of flow fluctuations.

2.5.2.6.1.8 SRSC Recovery Program

The SRSC have carried out 41 Salmon Recovery Program actions since 2000, including 29 fish screen installation projects that avoid and minimize juvenile salmonid and sDPS green sturgeon injury and death at agricultural diversions, four fish passage projects that improve fish passage to upstream spawning habitat and reduce straying into the Colusa Basin, and eight spawning and rearing habitat improvement projects that contribute to increased production and improved growth and survival of juvenile salmonids and sDPS green sturgeon.

The continuation of these actions are expected to result in long-term benefits to winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, and their designated critical habitats. The actions would also benefit fall-run Chinook salmon (which would provide benefits to southern resident killer whale by improving prey availability).

The anticipated long-term benefit associated with increasing the quantity and quality of spawning substrate in the upper Sacramento River will affect adult salmonids in particular as they return to spawn and may result in increased production over time. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in spawning habitat availability.

The benefits associated with increasing the quantity and access to quality side-channel and inchannel rearing habitat in the upper and middle Sacramento River will affect rearing and migrating juvenile salmonids and sDPS green sturgeon. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in rearing habitat availability.

The benefits associated with modifications to existing man-made structures from Keswick downstream to Verona will affect adult migrant and rearing and migrating juvenile salmonids and sDPS green sturgeon. The frequency of exposure is assumed to be high because completed restoration activities would result in a semi-permanent increase in rearing habitat availability.

2.5.2.6.1.9 SRSC Commitment to the Sacramento River Science Partnership

The Sacramento River Science Partnership (Partnership) will establish a general agreement, understanding, and framework for the establishment and implementation of the Mainstem Sacramento River Integrated Water and Fish Science and Monitoring Partnership between the

The scope, mission, and objectives of this Partnership are expected to improve the science that is used to protect and support the recovery of winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. The Partnership is also expected to provide benefits to sDPS green sturgeon and fall-run Chinook salmon and to result in benefits to SRKW since Chinook salmon are such an important prey base.

2.5.3 Trinity River Division (Clear Creek and Spring Creek Debris Dam)

During consultation for this Opinion, discussions between NMFS and Reclamation resulted in revisions to the PA that were not captured in the February 5, 2019, biological assessment.

Biological Opinion for the Long-Term Operation of the CVP and SWP

Sections 2.5.3.1-4, and 2.6.3.1 of the effects description below is based on the modeling associated with the February 5, 2019 PA (Appendix A1) and associated modeling that NMFS requested, and the April 30, 2019 PA (Appendix A2). Section 2.5.3.3 provides an effects analysis to assess the effects of the June 14, 2019 PA revisions reflected in the final PA (Appendix A3).

Reclamation operates the Trinity River Division to divert water to the Sacramento River system, and to ensure necessary flow releases into the Trinity-Klamath Basin. Operations are in coordination with the Shasta Division to: (1) support water supply and hydroelectric power generation for the CVP, (2) manage flood control, and (3) meet minimum flow and water temperature objectives within the Trinity River, Clear Creek, and Sacramento River.

PA components for the Trinity Division include (1) Whiskeytown Reservoir Operations, (2) Clear Creek Minimum Flows, (3) Clear Creek Channel Maintenance and Spring Attraction Pulse Flows, and (4) Spring Creek Debris Dam (ROC on LTO BA Table 4-6 [ROC on LTO BA]). A depiction of the deconstructed action describing how the PA components relate to each other is provided in Figure 2.5.3-1. The primary stressors influenced by each PA component are identified in Table 2.5.3-1. A full description of each stressor is found in the Stressor Introduction Section 2.5.1. The temporal and spatial occurrence of the listed species life stages is described in 2.5.3.1. The exposure, risk and response of each species to the project-related stressors are analyzed in the following sections for each PA component.

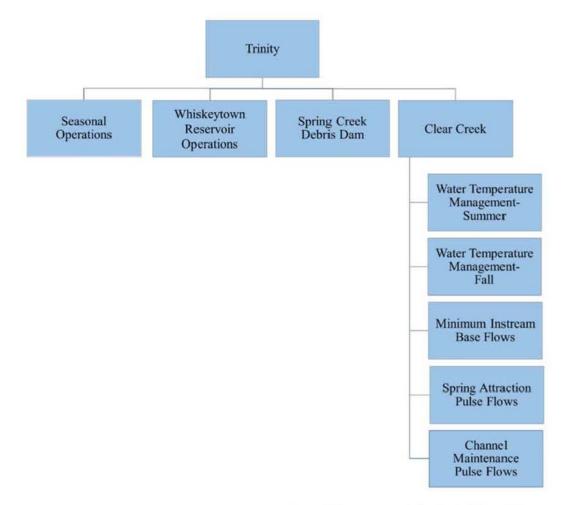


Figure 2.5.3-1. Deconstructed action describing the relation of PA components in the Trinity Division.

Table 2.5.3-1. Primary stressors influenced by the PA components covered in the Trinity River Division effects analysis.

Project Component	Passage Impediments/Barrier	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
Spring Creek Debris Dam	-	-	X	х	х	-	-	-				-	-	-	*1
Water Temperature Management - Summer	-		x	-	C#4		ь.			х				æ8	-

Project Component	Passage Impediments/Barrier	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
Water Temperature Management - Fall	-		X	2	(=)	-	ı	ĵ.	1	Х	i=	-	(E)	##X	*
Minimum Instream Base Flows	2	E	Х	2	х	·	х	x	9	ŭ	х	2		26	_
Spring Attraction Pulse Flows	340)JES	X	X	Х	X	X	1	J.	200	X			100	4
Channel Maintenance Pulse Flows	-		-	X	Х	Х	X	<u></u>	-	X	X	-			-

2.5.3.1 Temporal and Spatial Occurrence of Listed Salmonids in Clear Creek

2.5.3.1.1 CV Spring-run Chinook Salmon

Adult CV spring-run Chinook salmon migrate into Clear Creek from April to August, and peak passage occurs in May and June (Giovannetti and Brown 2013, Clear Creek Technical Team 2018). Adults distribute throughout Clear Creek and hold in deep pools throughout the summer from Whiskeytown Dam (RM 18.3) as far downstream as RM 4.

Whiskeytown Dam precludes historical access of CV spring-run Chinook salmon to the upper Clear Creek watershed, and there is not complete spatial or temporal separation between fall-run Chinook salmon and CV spring-run Chinook salmon during spawning (Giovannetti and Brown 2013). CV spring-run Chinook salmon migrate into Clear Creek several months before fall-run Chinook salmon migration begins. A large portion of the CV spring-run Chinook salmon typically moves to the upstream 10 miles of the creek, to hold in the colder water of the canyon. Before the arrival of fall run Chinook salmon, and just prior to the onset of CV spring-run Chinook salmon spawning, the USFWS installs and operates a temporary weir each year to physically separate the two runs during spawning to minimize hybridization and redd superimposition. The segregation weir is placed at RM 7.5 or 8.2 in late August and left in place until early November after the peak of fall-run Chinook salmon spawning when there is no chance of hybridization, and risk of redd superimposition is very low. The weir location and timing were determined to protect the most CV spring-run Chinook salmon, while minimizing effects to other salmonids (Giovannetti and Brown 2013). Any CV spring-run Chinook salmon downstream of the weir are likely to hybridize with fall-run Chinook salmon, or redds would be subject to redd superimposition.

Spawning occurs from early September through October, and peaks in late-September (Giovannetti and Brown 2013). Egg incubation occurs from September to early February based on redd timing. Based on juvenile passage indices from the USFWS rotary screw trap (RM 8.4), fry emergence begins in early November, peak passage occurs from mid-November through January, and a small number of juveniles and smolts are captured throughout the remainder of the monitoring season, which generally ends on July 1 annually (Earley et al. 2009, Schraml et al. 2018). While the majority of juvenile CV spring-run Chinook salmon outmigrate as fry, a portion rears in Clear Creek through the spring and summer, and emigrate as sub-yearlings. Juvenile CV spring-run Chinook salmon have been observed during snorkel surveys in the spring and summer months (U.S. Fish and Wildlife Service 2007).

2.5.3.1.2 CCV Steelhead

Adult CCV steelhead migration into Clear Creek begins in late-August and continues through April. CCV steelhead spawning begins in mid-December and continues through April, with peak spawn timing occurring from mid-December through early February. Spawning is distributed throughout the creek, with the majority of redds located downstream of RM 6 in recent years (Schaefer et al. 2019). Egg and alevins are present in redds from mid-December through June. Emergent fry are first observed in the rotary screw traps beginning in mid-January, and juvenile CCV steelhead are captured during all months of monitoring, which occurs from November through June (Schraml et al. 2018). Underwater observational surveys for various studies and fish rescue operations during restoration work by the USFWS have also documented the presence of juvenile CCV steelhead in the summer and fall months. Juvenile CCV steelhead rear in fresh water from one to three years. Multiple year classes of juvenile CCV steelhead rear in Clear Creek year round, and are distributed throughout the entire length of the creek. Based on rotary screw trap catch, smolts account for a low proportion of the juvenile passage indices. For example, in 2012, smolts accounted for 1.4 percent passage and were observed January through May (Schraml et al. 2018). However, larger-sized juveniles and smolts more easily avoid capture in the rotary screw traps, and passage estimates may underestimate these life stages.

2.5.3.1.3 Sacramento River Winter-run Chinook Salmon

On occasion, the USFWS has observed adult winter-run Chinook salmon and evidence of spawning in Clear Creek during monitoring since surveys began in 1999 (Newton and Brown 2004, Killam and Mache 2018). Video monitoring data at the mouth of Clear Creek has documented adults passing upstream, and although rare and intermittent, a few carcasses and redds have been reported over the years. Most recently, in July 2017, one redd was observed and three hatchery-tagged winter-run Chinook salmon carcasses were recovered (Clear Creek Technical Team 2019). Observations of winter-run Chinook salmon have only been made in the lower 6 miles of Clear Creek.

2.5.3.2 Seasonal Operations and Whiskeytown Reservoir Operations

The Trinity Reservoir supply and operations are in coordination with the Shasta Division to support water supply and hydroelectric power generation for the CVP, manage flood control, and meet minimum flow and water temperature objectives within the Trinity River, Sacramento River, and Clear Creek. The Department of the Interior's 2000 Trinity River Mainstem Fishery Restoration Record of Decision (2000 ROD) seasonally regulates trans-basin diversions to 55

percent of the approximately 1.2 MAF annual inflow on a 10-year average basis, which impacts Reclamation's temperature operations and CVP deliveries on the Sacramento River. Water diversions from the Trinity Division to the Shasta Division have averaged about 650,000 TAF per year from 2001-2018 (Trinity River Restoration Program).

Trinity River water is diverted from Lewiston Reservoir to Whiskeytown Reservoir through the Clear Creek Tunnel and Carr Power Plant. The diverted water flows through Whiskeytown Reservoir, and is diverted either into Spring Creek Tunnel, through Spring Creek Power Plant, and into Keswick Reservoir where it is released into the upper Sacramento River; or is released from Whiskeytown Dam into Clear Creek.

The Whiskeytown Reservoir Operations PA component includes: (1) regulation of inflows for power generation and recreation; (2) support of upper Sacramento River temperature objectives; and (3) providing releases to Clear Creek to meet water temperature objectives for CV spring-run and CCV steelhead. Whiskeytown Reservoir has a capacity of 241 TAF at the 1,210 feet reservoir surface elevation, and current operations build storage in the spring. It is drawn down by approximately 35 TAF from November through April to regulate wet-season runoff for winter and spring flood management. Heavy rainfall events and flood control management occasionally result in glory hole spillway discharges into Clear Creek. Although Whiskeytown Reservoir is primarily used as a conveyance system for trans-basin diversions, Reclamation operates both Carr and Spring Creek Power plants to generate electricity and maintain lake elevations for recreation. Hydroelectric power is also generated at the City of Redding power plant, located immediately downstream from Whiskeytown Dam. Whiskeytown Reservoir also supplies domestic water to the Clear Creek Community Services District.

The volume of water moving through Lewiston and Whiskeytown reservoirs affects Sacramento River and Clear Creek water temperatures. There are two temperature control curtains located in Whiskeytown Reservoir, designed to work in tandem to reduce mixing of cold water inflows and warm surface waters, and to enhance cold water availability to the Whiskeytown Reservoir outlets at Spring Creek Tunnel (1,085 ft. elevation) and Whiskeytown Dam (Vermeyen 1997, Clear Creek Technical Team 2018). The Oak Bottom Temperature Control Curtain (replaced in May 2016) is located at the Carr Powerplant Tailrace, and the Spring Creek Temperature Control Curtain (replaced in 2011) is located at the Spring Creek Tunnel intake (Clear Creek Technical Team 2018). The outlet works at Whiskeytown Dam has two intakes (the upper one at 1,100 ft. elevation, and the lower one at 972 ft. elevation) to release water into Clear Creek. Reclamation evaluates thermal profiles of Whiskeytown Reservoir throughout the year, and thermal stratification typically begins around April. The outlets access different water temperature zones in the stratified reservoir and can be operated to help manage downstream temperatures and conserve the cold-water pool. Reclamation proposes to continue providing temperature profile measurements for Whiskeytown and Trinity Reservoirs to support operational decisions for water temperature management.

While Trinity Seasonal Operations were included as a PA component, Reclamation did not specify any operational actions beyond water availability in Whiskeytown Reservoir. Whiskeytown Reservoir Operations related to Clear Creek releases include water temperature management, minimum instream base flows, and spring attraction and channel maintenance flows described in Section 2.5.3.4.

2.5.3.3 Spring Creek Debris Dam

After a consultation meeting on May 21, 2019, Reclamation provided an updated description of the Spring Creek Debris Dam PA component (Caramanian 2019), and a final PA on June 14, 2019 (Appendix A3), which included additional details that are summarized here. Because Reclamation did not provide an effects analysis of this PA component, we included some assumptions to determine effects to species and habitat.

Spring Creek Debris Dam was constructed to regulate runoff containing debris and acid mine drainage from Spring Creek, a tributary to the Sacramento River that enters Keswick Reservoir. Runoff containing acid mine drainage from Iron Mountain Mine is stored in Spring Creek Reservoir. In January 1980, Reclamation, CDFW, and SWRCB executed a memorandum of understanding (MOU) to implement actions that protect the Sacramento River system from heavy metal pollution from acid mine drainage in Spring Creek and adjacent watersheds. Since 1990, concentrations of toxic metals have been reduced by approximately 95 percent from what historically emptied into the Sacramento River (Caramanian 2019). This reduction was due to significant remedial actions by the EPA including the completion of (1) Minnesota Flats Iron Mountain Mine Acid Mine Drainage Treatment Plant in 1994, (2) Slickrock Creek Retention Reservoir in 2004 and, (3) dredging of contaminated sediments from the Spring Creek arm of Keswick Reservoir in 2009-2010. Due to improvements in water quality, operation of the Spring Creek Debris Dam and Shasta Dam have deviated from the 1980 MOU, and as a result, Reclamation CDFW, SWRGB and EPA are progressing towards a revised MOU with similar guidelines to what Reclamation is proposing for interim operations as part of this PA.

Reclamation is proposing to implement operational actions involving water releases at Spring Creek Debris Dam, Spring Creek Power Plant, and Keswick Reservoir, that result in meeting water quality criteria standards for concentrations of copper and zinc from acid mine drainage pollution from Spring Creek at a compliance point in the Sacramento River, to protect aquatic life. Reclamation proposes to conduct water quality monitoring, and with increased frequency during Spring Creek Debris Dam spillway releases, or when there are drops below the minimum elevation threshold in Spring Creek Reservoir. The operation described herein is also dependent on the water treatment capabilities afforded by EPA.

Storage elevation levels in Spring Creek Reservoir determine the operational action used to maintain water quality criteria in the Sacramento River. Actions include (1) undiluted controlled releases when storage is between 720 and 795 feet, typically December through June, (2) dilution releases through the spillway, combined with increased releases from Keswick Dam, when storage exceeds 795 feet, and (3) no releases from the reservoir when storage is below 720 feet, and instead a minimum dilution flow of 250 cfs from Spring Creek Power Plant. Reclamation operates to maintain Spring Creek Reservoir storage elevation between 720 and 795 feet, and Reclamation assumes operational scenarios for levels above or below this range would occur very infrequently.

In the unlikely situation when the Spring Creek Debris Dam spillway is used, Reclamation anticipates an "emergency" relaxation of EPA's criteria for a 50 percent increase in the objective concentrations of copper and zinc. Although the general operational goal is to avoid use of the Spring Creek Debris Dam spillway, some storm events or series of events are unavoidable. The spillway operation typically occurs during a large storm or series of events, January through April, and are coincident with large flood management flows released from Keswick Dam. In

recent years EPA, Reclamation, CDFW, and the RWQCB have agreed not to use the emergency criteria until a spill is imminent. During significant rain events Spring Creek Debris Dam releases may target a dilution ratio with Keswick releases to achieve an acceptable water quality below Keswick Dam. Spring Creek Reservoir spillway dilution flows from Keswick are expected to be coincident with large flood management flows and are not expected to impact water supply or cold-water pool resources. Reclamation also does not plan to operate Spring Creek Reservoir below 720 feet elevation to avoid potentially significant degraded water quality when reservoir soils are exposed, and assumes this would only occur in a very rare situation. Any time dilution flows are necessary, Reclamation's objective is to minimize the build-up of toxic metals in the Spring Creek arm of Keswick Reservoir. To accomplish this, the releases from the debris dam are coordinated with releases from Spring Creek Powerplant (Spring Creek Power Plant draws water from Whiskeytown Reservoir) to keep the metals in circulation within the main body of Keswick Reservoir.

2.5.3.3.1 Sacramento River Winter-run, CV Spring-Run Chinook Salmon, CCV Steelhead, and Green Sturgeon Exposure, Response, and Risk

In conjunction with the EPA remedial actions, the proposed operation of Spring Creek Debris Dam will be operated to decrease concentration levels of zinc and copper entering the Sacramento River, and minimize adverse physiological effects to listed salmonids and green sturgeon.

Spring Creek Debris Dam spillway releases will likely only occur during large storms from January through April when the Spring Creek Reservoir is over 795 feet, resulting in higher flows into the Sacramento River. In addition, higher Keswick releases will be needed to dilute contaminants being spilled from the Spring Creek Debris Dam, and achieve the water quality criteria level below Keswick Dam. Increased Keswick releases during these months, may result in a decrease of Shasta Reservoir storage, and have the potential to impact water supply and cold-water pool resources reserved for summer and fall months for the Sacramento River. Warmer releases into the Sacramento River may occur resulting in exposure to unsuitable water temperatures for CV spring run and Sacramento River winter-run Chinook salmon, spawning, and egg incubation. Because Spring Creek Reservoir spillway dilution flows from Keswick are expected to coincide with large flood management flows, they are not expected to impact water supply or cold-water pool resources. Flow changes in the Sacramento River between January and June have the potential to impact CCV steelhead spawning and juvenile CV steelhead, Sacramento River winter-run, and CV spring-run Chinook salmon rearing. Large increases may expose salmonid embryos in redds to risk of scour and fine sediment infiltration, and flow decreases may strand or isolate juvenile salmonids in side channels downstream of Keswick Dam.

On the rare occasion when Spring Creek Reservoir is below 720 feet storage elevation and increased releases from Spring Creek Powerplant are needed for dilution flows, additional water draw from Whiskeytown Reservoir may impact cold-water pool resources. Warmer releases from the reservoir into Clear Creek during CV spring-run Chinook salmon holding, spawning, and egg incubation could result in decreased egg survival.

In any operational scenario, NMFS expects contaminants to remain within standards and physiological effects of contaminants on listed fish are not expected to occur. Reclamation will

monitor water quality in the Sacramento River as described in the 1980 MOU, and with increased sampling frequency during dilution flows, and altered operations if necessary to ensure levels of contaminants are within standards.

Reclamation expects to maintain reservoir levels, such that dilution flow operations are not expected to occur. As the EPA treatment plant is the first defense to keeping acid mine pollution within water quality standards in the Sacramento River, NMFS adopts Reclamation's assumption regarding proposed operation of Spring Creek Debris Dam. Therefore, exposure to Sacramento River flow, water temperature, or contaminant stressor effects in Clear Creek are not expected to occur to extents that would result in impacts to listed species.

2.5.3.4 Clear Creek

This section addresses the portion of Trinity River Division water that is diverted into Whiskeytown Reservoir and becomes part of Clear Creek releases. Reclamation proposes to provide releases from Whiskeytown Dam into Clear Creek to: (1) to meet water temperature objectives for CV spring-run and CCV steelhead, (2) provide minimum instream base flows, and (3) create pulse flows for both attraction of adult CV spring-run Chinook salmon and channel maintenance. In years when channel maintenance flows do not occur, Reclamation proposes to use mechanical methods to mobilize gravel or shape the channel, if needed, to meet biological objectives. Each PA component and their effects on listed species in Clear Creek are described below.

2.5.3.4.1 Clear Creek Temperature Management

Reclamation proposes to manage Whiskeytown Dam releases to meet a daily average water temperature of (1) 60°F from June 1 through September 14, and (2) 56°F or less from September 15 to October 31 at the U.S. Geological Survey Igo stream gaging station (IGO), located at RM 11.0 on Clear Creek (U.S. Geological Survey 2019). In Critical or Dry water year types (based on the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification [California Data Exchange Center (Department of Water Resources 2019)], Reclamation will operate to as close to these temperatures as possible, but acknowledges temperature criteria may not be met. During the water temperature management period, Reclamation proposes to increase minimum instream base flows when needed to meet criteria.

Water temperature criteria in the PA are the same as current operations, which were developed to reduce thermal stress to CV spring-run Chinook salmon during holding, spawning, and embryo incubation, and over-summering CCV steelhead.

The amount of cold-water pool available depends on carry-over storage, reservoir water temperature, and the amount, timing, and water temperature of inflows from Trinity Reservoir through Whiskeytown Reservoir to Keswick Reservoir and Clear Creek. Since the Trinity River 2000 ROD flows were first implemented in 2005, temperature compliance of 56°F or less during the September 15 to October 31 spawning period (as discussed below) has been more difficult to meet due to changes in water diversion patterns that have resulted in longer residency time and warming in Whiskeytown Reservoir. By September, the cold-water pool in Whiskeytown becomes limited, and in some cases may result in less cold water available for Clear Creek during the CV spring-run Chinook salmon spawning period. Operational strategies that have been used to offset this limited cold water availability have included early recognition to use

different outlet configurations at Whiskeytown Dam to conserve and access colder water during periods of thermal stress (He and Marcinkevage 2016). Additional operational strategies that have been used in the summer to conserve cold water for the CV spring-run Chinook salmon spawning period include reducing Clear Creek releases in July, and avoiding full power peaking operations at Trinity, Carr and Spring Creek powerhouses (Clear Creek Technical Team 2013). The recent replacement of the torn temperature control curtains in Whiskeytown Reservoir are expected to help to provide more cold water, and Reclamation's Technical Service Center is currently evaluating of the performance of both temperature curtains, with a final report expected in 2019.

For the Clear Creek analysis, Reclamation used the HEC-5Q model, to simulate temperature conditions on the rivers affected by CVP and SWP operations, using CalSimII output for Whiskeytown Reservoir. Output was provided for three locations: Whiskeytown Dam (RM 18), IGO temperature compliance point (RM 11), and the confluence of Clear Creek and the Sacramento River. The current operating scenario (COS) refers to the current modeling representation of project operations at the time of consultation. Because the proposed temperature management is the same as current operations, the PA and COS modeling results are similar.

To evaluate thermal conditions for adult and juvenile salmonids in Clear Creek, exceedance plots of monthly mean water temperatures were examined with consideration of the temperature criteria under various water year types (Figure 2.5.3-2). While monthly exceedance plots are useful for assessing the conditions that the PA component will provide monthly, they do not reflect the daily water temperature that occurs. In addition, because the temperature criterion changes on September 15, it is difficult to compare monthly temperatures to the different criterion period.

HEC-5Q modeling results showed that water temperature objectives are met at IGO each month under the PA component, except in Critical water year types, which are expected to occur in 15 percent of years (Table 2.5.3-2). In Critical water year types, monthly average temperatures exceeding 56°F are expected to occur approximately 7 percent of the time in September and October (Figure 2.5.3-2).

Table 2.5.3-2. HEC-5Q modeling results at the IGO gaging station temperature criteria compliance point for the proposed action. Results include monthly average water temperatures and probability of exceedance, and mean monthly water temperature under the different water year types (source: ROC on LTO BA, Appendix D, Attachment 3-4, Table 3-3).

					Mont	hly Temper	ature (DEG	i-F)				
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	55.0	52.2	48.7	46.3	46.1	47.3	49.1	50.3	53.1	56.6	56.6	55.6
20%	54.2	51.8	48.2	45.6	45.6	46.9	48.6	49.9	52.5	56.0	56.2	54.7
30%	53.8	51.1	47.1	45.2	45.2	46.5	48.1	49.4	51.9	55.4	55.7	54.3
40%	53.4	50.9	46.8	44.9	45.0	46.1	47.9	49.2	51.6	55.2	55.6	54.0
50%	53.0	50.6	46.5	44.6	44.8	45.9	47.6	48.9	51.2	55.0	55.3	53.5
60%	52.4	50.4	46.3	44.3	44.5	45.7	47.4	48.6	50.9	54.6	55.2	53.1
70%	51.8	50.2	46.1	44.1	44.2	45.5	47.2	48.4	50.7	54.5	54.9	52.9
80%	51.2	49.8	45.9	43.9	44.0	45.3	46.9	48.1	50.3	54.2	54.5	52.4
90%	50.7	49.4	45.5	43.6	43.8	44.8	46.4	47.4	49.6	53.8	54.0	52.1
Long Term												
Full Simulation Period ^a	53.0	50.8	46.9	44.8	44.9	46.0	47.7	48.9	51.4	55.0	55.3	53.8
Water Year Types b,c												
Wet (32%)	51.4	50.1	46.5	44.5	44.5	45.5	47.2	48.6	50.9	54.9	55.0	52.8
Above Normal (16%)	51.9	50.1	46.4	44.6	44.6	45.7	47.4	48.7	50.9	54.8	54.9	52.7
Below Normal (13%)	53.1	51.0	46.8	44.2	44.5	45.9	47.6	48.5	50.9	55.0	55,2	53.5
Dry (24%)	53.6	51.1	47.2	45.0	45.1	46.3	47.9	48.9	51.3	55.0	55.7	54.2
Critical (15%)	56.3	52.3	47.5	45.7	46.0	47.2	48.9	50.1	53.4	55.5	56.2	56.7

^a Based on the 82-year CalSimII simulation period.

^b As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).

^c These results are displayed with calendar year type sorting.

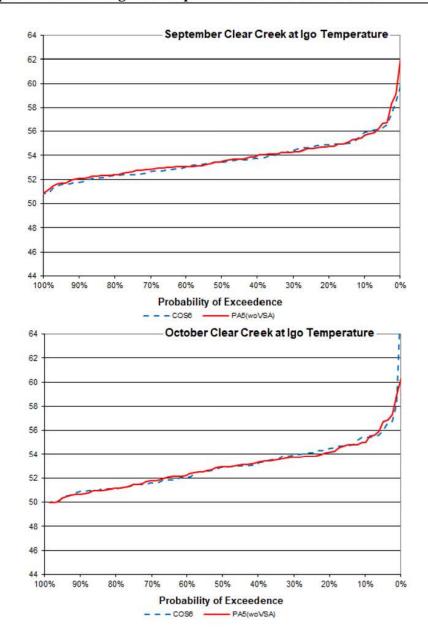


Figure 2.5.3-2. HEC-5Q modeling result exceedance plots based on the 82-year CalSimII simulation period, in September and October at the IGO gaging station temperature compliance point. Plots compare the Current Operating Scenario (COS6) to the Proposed Action (PA5woVSA), and the probability that monthly average water temperatures (degrees Fahrenheit) will occur. Because the temperature criteria changes on September 15, it is difficult to compare monthly temperatures to the different criteria periods (source: ROC on LTO BA, Appendix D, Attachment 3-4, Figure 3-7 and Figure 3-18).

The water temperature criteria as proposed, have been in place in Clear Creek since 1999. Since 1999, daily average water temperatures have generally been below 60°F at IGO during the summer holding period (Figure 2.5.3-3). However, water temperatures have exceeded 56°F

during the spawning period, and exceedance occurs more frequently in drier water year types (Figure 2.5.3-4, Figure 2.5.3-4). In general, exceedance occurs when the cold-water pool is depleted in Whiskeytown Reservoir.

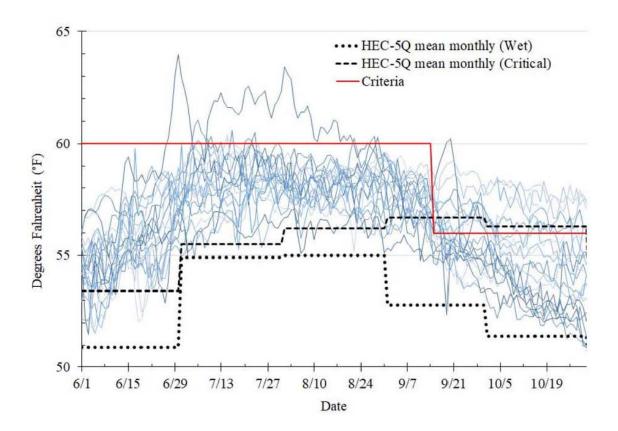


Figure 2.5.3-3. Daily average water temperatures during the water temperature management season. (Criterion=60 °F from June 1-Sept 14; and ≤56°F September 15-October 31) at the U.S. Geological Survey IGO, located at RM 11.0 on Clear Creek, 1999-2018. The PA HEC-5Q monthly water temperature modeling results during Sacramento Valley Index water year type Critical and Wet are shown for comparison.

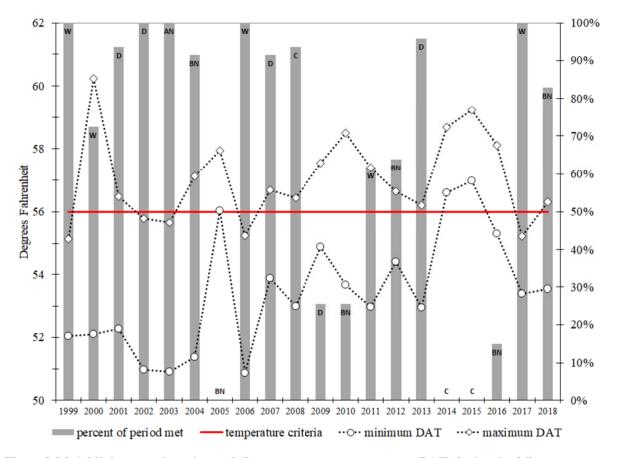


Figure 2.5.3-4. Minimum and maximum daily average water temperatures (DAT) during the fall water temperature management period (Sept 15-Oct 31) for CV spring-run Chinook salmon spawning, when DAT at the U.S. Geological Survey Igo stream gaging station (IGO), located at RM 11.0 on Clear Creek, are managed to ≤56°F, 1999-2018. Bars correspond to the y axis on the right, and represent the percent of days DAT were met within the period, and indicate the Sacramento Valley Index water year type (W=wet; AN=above normal; BN=below normal; D=dry; and C=critical).

The mouth of Clear Creek is the downstream extent of (1) juvenile rearing habitat and outmigration of CV spring-run Chinook salmon and CCV steelhead, and (2) CCV steelhead spawning habitat. Water temperatures at the mouth during the temperature management season generally represent the warmest temperatures in Clear Creek. The mouth is also the entry point of upstream adult migration where water temperatures are first experienced. Daily average water

temperature measurements near the mouth of Clear Creek from 1999 to 2018 (

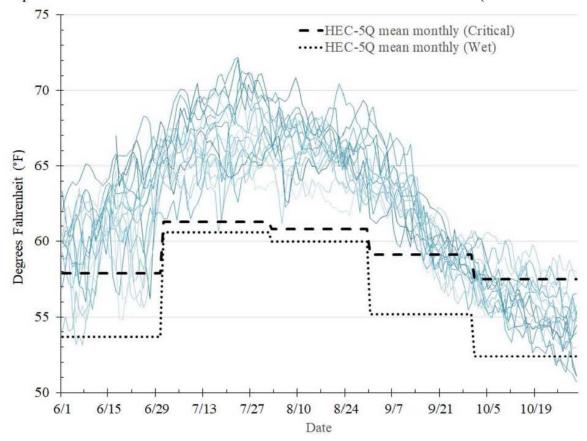


Figure 2.5.3-5), range above HEC-5Q monthly modeled temperatures during the temperature compliance period (Table 2.5.3-3, Figure 2.5.3-5). The discrepancy between actual and modeled temperatures may be due to differences in locations. Particularly in the summer months when the Sacramento River releases are high, flows create backwater into Clear Creek and cool the mouth, which may be influencing the model results.

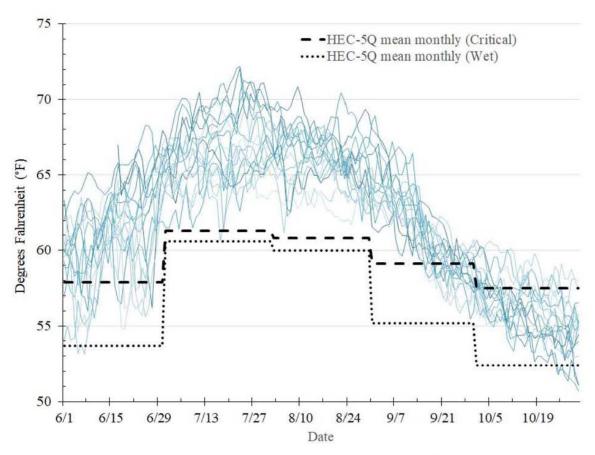


Figure 2.5.3-5. Daily average water temperatures during the temperature compliance period near the mouth of Clear Creek for the years 1999-2018 (Chamberlain 2019c). The PA HEC-5Q monthly water temperature modeling results during Sacramento Valley Index water year type Critical and Wet are shown for comparison.

Table 2.5.3-3. HEC-5Q modeling results at the mouth of Clear Creek for the proposed action. Results include monthly average water temperatures and probability of exceedance, and mean monthly water temperature under the different water year types (source: ROC on LTO BA, Appendix D, Attachment 3-4, Table 4-3).

	Monthly Temperature (DEG-F)											
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	56.0	52.6	48.9	46.6	46.6	48.4	50.9	52.1	56.9	62.2	61.4	57.7
20%	55.1	52.1	48.3	45.9	46.3	48.2	50.3	51.8	55.5	61.7	61.0	56.9
30%	54.6	51.6	47.4	45.5	45.9	47.9	49.8	51.3	54.9	61.1	60.7	56.6
40%	54.2	51.2	47.0	45.3	45.8	47.4	49.5	50.9	54.5	60.8	60.5	56.3
50%	53.9	50.9	46.8	44.9	45.5	47.0	49.2	50.7	54.1	60.6	60.2	55.8
60%	53.1	50.7	46.5	44.7	45.2	46.9	49.1	50.5	53.8	60.4	60.1	55.4
70%	52.7	50.5	46.3	44.3	45.0	46.6	48.9	50.2	53.4	60.1	59.8	55.2
80%	52.2	50.1	46.1	44.1	44.7	46.4	48.5	49.9	53.1	59.9	59.4	54.8
90%	51.8	49.7	45.6	43.9	44.5	45.9	48.1	49.1	52.5	59.5	59.1	54.4
Long Term												
Full Simulation Perioda	53.9	51.1	47.0	45.1	45.6	47.2	49.4	50.8	54.5	60.7	60.2	56.1
Water Year Types b,c												
Wet (32%)	52.4	50.4	46.7	44.9	45.2	46.6	48.8	50.4	53.7	60.6	60.0	55.2
Above Normal (16%)	52.8	50.4	46.6	45.0	45.3	46.9	49.0	50.6	53.8	60.5	59.8	55.0
Below Normal (13%)	53.9	51.3	47.0	44.5	45.2	47.0	49.4	50.3	53.8	60.6	60.0	55.7
Dry (24%)	54.5	51.4	47.4	45.2	45.8	47.5	49.6	50.7	54.3	60.7	60.6	56.4
Critical (15%)	57.5	52.7	47.6	46.0	46.8	48.5	50.9	52.3	57.9	61.3	60.8	59.1

^a Based on the 82-year CalSimII simulation period.

2.5.3.4.1.1 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

The water temperature management season encompasses the CV spring-run Chinook salmon adult holding, spawning, and egg incubation/alevin development life stages, and ends just prior juvenile emergence. A small number of sub-yearling juveniles are present during the temperature management season.

The PA HEC-5Q monthly water temperature modeling results during the summer water temperature management period (60°F at IGO from June 1-September 14) show average monthly water temperatures well below the 60°F criterion from June-August in all water year types (Table 2.5.3-3 and Figure 2.5.3-3). Under current operations, daily average water temperatures at IGO from 1999-2018 were consistently warmer than what was modeled for the PA (Table 2.5.3-3 and Figure 2.5.3-3). Daily average water temperatures have only exceeded 60°F at IGO for a few days in some years under current operations (except in 2000, when flow releases were low to accommodate the removal of Saeltzer Dam). Under current operations, average monthly summer base flows in July and August have ranged between 50 cfs and 180 cfs. Base flows greater than 150 cfs have been released in Critical water year types under current operations to meet water temperature criterion in the summer, and will likely be needed under the PA. Use of higher base flows in the summer may degrade the cold-water pool in Whiskeytown Reservoir, decreasing the ability to meet fall spawning water temperature criterion.

^b As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).

^c These results are displayed with calendar year type sorting.

At the mouth of Clear Creek from June through August, water temperatures greater than 68°F create a passage impediment, lowering adult returns. Adult CV spring-run Chinook salmon migration into Clear Creek continues through the temperature management period, with approximately 35 percent of the population index passing in June, and very low numbers passing in July and August. Daily average water temperatures near the mouth of Clear Creek from 1999 to 2018 were generally within optimal ranges for adult migration in June; suboptimal (>68°F) during some periods in July and August; and occasionally over 70°F (when migration generally stops) in July (Figure 2.5.3-5). The low rate of migration in July and August is likely due to life history characteristics of CV spring-run Chinook salmon in the Upper Sacramento tributaries, and temperature-related migration barriers associated with warmer water at the confluence of Clear Creek. Temperature and low flow barriers at riffles and cascades may inhibit access to the upper watershed in the summer.

Daily average water temperatures are likely to continue to remain below 60°F upstream of the IGO compliance point under the PA based on HEC-5Q temperature modeling results, and observed daily average water temperature data under current operations (Figure 2.5.3-3). However, monitoring from 2003-2016 has shown that, annually, an average 49 percent (range = 25 to 73 percent) of the adult CV spring-run Chinook salmon population index is located downstream of the IGO temperature compliance point at RM 11.0 (Figure 2.5.3-6); these fish are therefore more likely to be exposed to water temperatures greater than 60°F. In addition, after the segregation weir is installed in late August, an average of 20 percent (range 1 to 36 percent) of the population index is located downstream of the segregation weir at RM 8.2 or 7.5 (Figure 2.5.3-6) and as far downstream as RM 4, where in some years, daily average water temperatures reach over 65°F (Clear Creek Technical Team 2016). The CV spring-run Chinook salmon adults downstream of the segregation weir are also subject to hybridization with fall-run Chinook salmon, and their incubating eggs would be exposed to impacts from suboptimal temperatures, and redd superimposition by fall-run Chinook salmon.

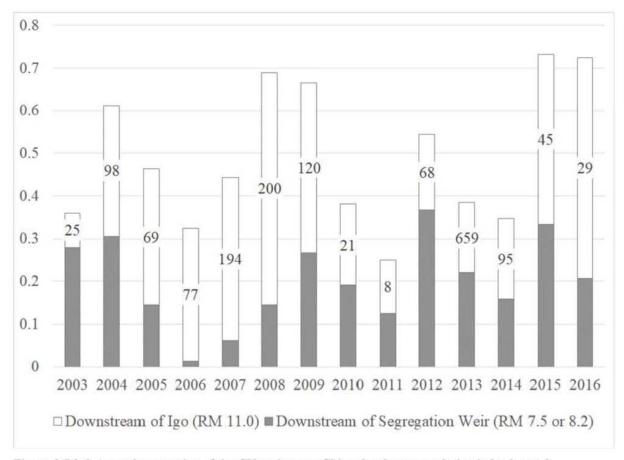


Figure 2.5.3-6. Annual proportion of the CV spring-run Chinook salmon population index located downstream of the IGO temperature compliance point (RM 11), and downstream of the segregation weir (RM 7.5 or 8.2), in Clear Creek, 2003-2016. Label at each stacked bar represents the annual population index (Chamberlain 2019b).

Cumulative exposure to stressful water temperatures can lead to increased risk of disease, decreased fecundity, prespawn mortality, and decreased reproductive success in adult CV springrun Chinook salmon. While daily average water temperatures are likely to remain below 60°F upstream of the IGO compliance point under the PA and to provide suitable holding habitat during the summer water temperature management period, the current adult CV spring-run Chinook salmon holding distribution pattern will likely continue under the PA, and therefore a high percentage of the population will be exposed to suboptimal water temperatures each year.

During the fall water temperature management period (≤56°F at IGO from September 15-October 31) the PA HEC-5Q monthly water temperature modeling shows difficulty meeting temperatures in Critical water year types, which are expected to occur in 15 percent of years. The PA states that meeting temperatures in Dry water year types may be difficult as well. From 1999 to 2018, the temperature criterion has been exceeded during the spawning period in 14 of 19 years (excluding 2000) at IGO, and exceedance has not been limited to Dry and Critical water year types (Figure 2.5.3-4). The temperature criterion was exceeded during the entire spawning period in 2005, 2014, and 2015 (Figure 2.5.3-4). Additionally, in 4 years (2009, 2014-2016)

average daily water temperatures continued to be above 56°F at the Whiskeytown Dam outlet, and at IGO, through mid-November. From 2003-2016, results from monitoring data have shown an average of 42 percent (range=30 to 64 percent) of the CV spring-run Chinook salmon redd index (redd count from Whiskeytown Dam to the segregation weir at RM 7.5 or 8.2) was located downstream of the temperature compliance point at IGO (Figure 2.5.3 7). In addition, an average of 8 percent (range = 0 to 26 percent) of the CV spring-run Chinook salmon annual redd index begins before September 15 (Provins 2019a), which would be exposed to the 60°F summer water temperature management period.

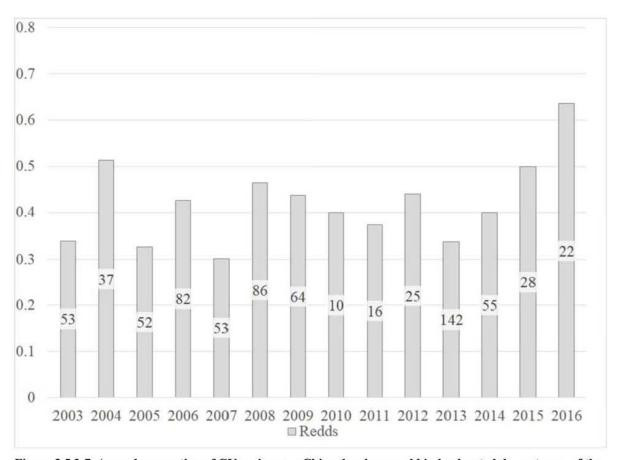


Figure 2.5.3-7. Annual proportion of CV spring-run Chinook salmon redd index located downstream of the IGO temperature compliance point (RM 11) in Clear Creek, 2003-2016. Labels at each bar represent the annual redd index (redd count between Whiskeytown Dam (RM 18.3) and the segregation weir at RM 7.5 or 8.2) (Chamberlain 2019b).

Spawning gravel additions have created suitable spawning habitat in a 1-mile reach downstream of IGO, and a large portion of redds are located here each spawning season. Incubating eggs are exposed to different water temperatures depending on redd location. In general, redds located further upstream experience colder water temperatures in Clear Creek, especially during the earliest stages of incubation. In an evaluation of water temperature exposure at Clear Creek CV

spring-run Chinook salmon redd locations, from 2008-2018, eggs experienced mean daily temperatures over 56°F for approximately 25 percent of incubation days (Figure 2.5.3-

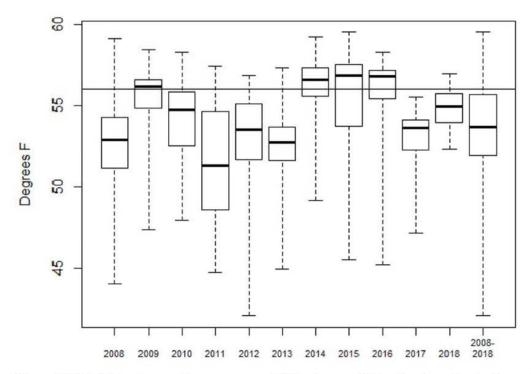


Figure 2.5.3-8. Water temperature exposure of CV spring-run Chinook salmon incubating embryos in Clear Creek, 2008-2018. Exposure was calculated using daily average water temperatures at redd locations through emergence. Loggers are about every two miles, and temperatures are interpolated to the redds, Lines in boxes are sample medians, box-ends are upper or lower quartiles, whiskers are minimum and maximum (Provins 2019b).

The 56°F daily average water temperature criterion was incorporated into the 2009 NMFS Opinion RPA to protect developing CV spring-run Chinook salmon eggs during the incubation period in Clear Creek. However, 56°F daily average water temperatures are suboptimal, and would likely lead to mortality of incubating eggs and reduced survival. Myrick and Cech (2004) determined that water temperatures between 6.1°C (43°F) and 12.2°C (54°F) appear best suited for Chinook salmon egg incubation and larval development. Modeling results from Martin et al. (2017) showed thermal mortality thresholds during the embryonic life stage of Chinook salmon in the Sacramento River were lower than what was previously documented in the laboratory, and hypothesized that egg survival was influenced by mechanisms including water velocity and oxygen in the water around the eggs within the redd. The EPA recommends the use of 13°C (55.4°F) maximum 7-day average of daily maxima (7DADM) criterion for Chinook salmon spawning (U.S. Environmental Protection Agency 2003).

After observing high temperature-dependent mortality for winter-run Chinook salmon on the Sacramento River, especially in 2014 and 2015, a new management target using 53.0°F or

53.5°F mean daily temperature at the most downstream redd location (as a surrogate for 55°F 7DADM) was implemented during spawning and incubation from 2016 through the present. Results from NMFS' Southwest Fisheries Science Center (SWFSC) temperature-dependent egg mortality model in those years have shown decreased temperature-dependent mortality and improved egg-to-fry survival (National Marine Fisheries Service 2019d). A recent evaluation of the relationship of flow and water temperature on CV spring-run Chinook salmon egg-to-fry survival in Clear Creek similarly concluded that lower water temperatures led to improved survival (Provins 2018). In developing a framework for incorporating water temperatures into recommended flow regimes, He and Marcinkevage (2016) found that reduced numbers of adult and juvenile CV spring-run Chinook salmon in Clear Creek were associated with higher water temperatures that occurred during migration, spawning, and rearing periods.

Capture of juvenile CV spring-run Chinook salmon in the Clear Creek rotary screw trap has demonstrated that successful spawning occurs annually. In some years, temperature-dependent mortality and reduced egg-to-fry survival likely contributed to lower than expected juvenile passage indices, based on redd counts. Because there are many physical variables that influence egg-to-fry survival (e.g. levels of dissolved oxygen, fine sediment infiltration in redds, flow and redd scour events), and environmental conditions and error associated with sampling sometimes add uncertainty to passage indices, differentiating temperature-associated mortality from other factors is complicated.

Since the implementation of the 2000 ROD in 2005, the 56°F spawning period criterion was exceeded in 12 of 14 years, and NMFS expects this to continue to occur in similar frequency under the PA. Clear Creek CV spring-run Chinook salmon redd distribution and water temperature data under current operations also demonstrate that incubating eggs are exposed to water temperatures greater than 56°F annually. In addition, literature suggests that daily average temperature of 56°F is suboptimal for Chinook salmon egg incubation (e.g., U.S. Environmental Protection Agency 2003, Myrick and Cech 2004, Martin et al. 2017, National Marine Fisheries Service 2019d).

While the majority of juvenile CV spring-run Chinook salmon emigrate by early spring, based on annual juvenile passage indices from the rotary screw trap, a small number rear in Clear Creek through the spring and summer and emigrate as sub-yearling smolts and therefore would be present during the water temperature management period. Observations of juvenile CV spring-run Chinook salmon have been made during snorkel surveys in the late spring and summer months (U.S. Fish and Wildlife Service 2007). Daily average water temperatures from 1999 to 2018 ranged from approximately 55°F to 60°F in July and August at IGO (Figure 2.5.3-3), but were generally greater than 65°F near the mouth (Figure 2.5.3-5). Under the PA, water temperatures upstream of IGO and for approximately 8 miles downstream would likely be within optimal ranges for juvenile rearing. Any juveniles rearing in the furthest downstream three miles of Clear Creek during the water temperature management period would likely be exposed to suboptimal temperatures for rearing (>65°F) and for smoltification (>66.2°F), increasing their susceptibility to stress, disease, predation, and mortality. However, based on the typical CV spring-run Chinook juvenile outmigration period, a very small number are expected to be present in summer months, and even less would be located in the lower three miles where water temperatures are suboptimal. Water temperature management under the PA is not expected to affect survival of rearing and outmigrating juveniles.

2.5.3.4.1.2 Sacramento River Winter-run Chinook Salmon Exposure, Response, and Risk

Winter-run Chinook salmon adults, carcasses and redds have been observed intermittently in the lower six miles of Clear Creek during monitoring surveys. Based on their spawn timing from May through August, redds located downstream of the IGO temperature compliance point under the PA would be exposed to suboptimal and lethal water temperatures, resulting in high rates of temperature-dependent mortality during the egg incubation period. In some years since 2000, water temperatures in Clear Creek within the first mile downstream of Whiskeytown Dam were suitable during the winter-run Chinook salmon egg incubation period; this would also likely occur under the PA. However, based on the very small number of adult winter-run Chinook salmon that are expected to spawn in Clear Creek, and the likelihood that spawning will occur downstream of RM 6, any redds that are constructed are expected to be exposed to warm water temperatures, and successful egg incubation is unlikely.

Juvenile winter-run Chinook salmon from the Sacramento River may rear in Clear Creek downstream of the Anderson-Cottonwood Irrigation Diversion (ACID) crossing at approximately RM 1.5. Non-natal rearing is limited to this location because the sheet pile dam protects the ACID irrigation pipe that crosses Clear Creek, creates an upstream migration barrier for juvenile salmonids. Water temperatures during fall water temperature management would provide additional suitable juvenile rearing habitat outside of the Sacramento River, increasing survival.

2.5.3.4.1.3 CCV Steelhead Exposure, Response, and Risk

Migrating adults and rearing juveniles from various year classes would be present in Clear Creek during the temperature management period. Various age-classes of juvenile CCV steelhead are distributed throughout Clear Creek year-round. The warmest water temperatures occur during the summer months with potential negative impacts to the returning adults, and rearing juveniles. Depending on the length of exposure, suboptimal water temperatures can affect growth rates, increase risk of predation and susceptibility to disease, inhibit smoltification, and cause direct mortality in all life stages of CCV steelhead (U.S. Environmental Protection Agency 2003). Specifically for adults, exposure to suboptimal temperatures prior to spawning inhibit migration, increase susceptibility to disease, reduce egg viability, and increase rates of prespawn mortality.

Water temperatures may be suboptimal for adult CCV steelhead during the earliest migration and holding period. Within the temperature management period, based on preliminary adult passage data from the video monitoring station located at the mouth of Clear Creek from 2014 to 2018, an average of 40 percent (range 12-71 percent) of adult CCV steelhead migrated into Clear Creek from mid-August through October (Cook 2019, Killam 2019). Only a small portion (average 6 percent) enter Clear Creek before September 15, before flow releases increase and the temperature criterion is reduced to 56°F.

Daily average water temperatures near the mouth of Clear Creek generally range from 60-70°F from mid-August to September 15, and are below 60°F consistently beginning in October (Figure 2.5.3-5). Based on a literature review of salmonid water temperature criteria, Richter and Kolmes (2005) summarized that water temperatures near 70°F block steelhead migration, and recommended 60.8°F weekly mean daily temperature and 64.4°F 7DADM as criterion for adult salmonid migration. The EPA recommends migration temperatures between 18°C (64.4 °F) and

20°C (68°F) 7DADM for Chinook salmon and steelhead to prevent migration blockage and increased risk of disease (U.S. Environmental Protection Agency 2003).

Because daily average water temperatures at the mouth are generally below 60°F during the majority of the CCV steelhead migration period, and only a small proportion of the annual return occurs before mid-September when water temperatures exceed optimal ranges, impacts to migrating adult CCV steelhead are not expected during the water temperature management period. In addition, migration timing often corresponds to the evening hours, when water temperatures are cooler. CCV steelhead adults hold in Clear Creek until spawning begins in mid-December, and are restricted downstream of the segregation weir until early November when it is removed. Water temperatures are generally adequate for holding during this time, and therefore not expected to reduce egg viability or survival of adult CCV steelhead. Due to the winter spawn timing, the CCV steelhead egg/alevin life stages would not be exposed to the PA summer or fall temperature management regimes.

In addition to protection for holding adult CV spring-run Chinook salmon, summer temperature management was designed to protect over-summering rearing juvenile CCV steelhead. Richter and Kolmes (2005) reported ideal conditions for CCV steelhead juvenile growth to be below 19°C (66.2°F), and optimal at 14-15°C (57.2-59°F). Frequency of anadromy in the early freshwater life stages of *O. mykiss* may be influenced by environmental factors, including stream temperatures, genetic factors, and individual condition (Kendall et al. 2014). Sloat and Reeves (2014) found significantly increased rates of anadromy in juvenile *O. mykiss* reared in warmer temperatures (seasonally adjusted temperatures between 6 and 18°C [42.8-64.4°F], compared to 6 and 13°C [42.8-55.4°F]).

During July and August, historically months with the warmest water temperatures observed in Clear Creek, the PA HEC-5Q modeling results at IGO and the mouth showed monthly average water temperatures are generally within optimal ranges for juvenile CCV steelhead rearing and growth (Table 2.5.3-2 and Table 2.5.3-3). Daily average water temperatures from 1999 to 2018 ranged from approximately 55°F to 60°F in July and August at IGO (Figure 2.5.3-3), but generally ranged from approximately 65°F to 70°F near the mouth at the lowest extent of rearing habitat (Figure 2.5.3-5). The highest density of CCV steelhead spawning occurs in the lower 6 miles of Clear Creek. Any juveniles rearing in the furthest downstream 3 miles of Clear Creek during the summer water temperature management period would likely be exposed to suboptimal temperatures, increasing their susceptibility to stress, disease, predation, and mortality. However, CCV steelhead juvenile outmigration generally does not occur in the summer so they would not be exposed to the warmest water temperatures at the mouth, and rearing juveniles would access upstream habitat with suitable water temperatures. Based on fresh-water rearing life history of juvenile CCV steelhead, which is 1-3 years, a large portion are expected to be present in Clear Creek during the summer months. However, the majority are expected to access rearing habitat with suitable water temperatures, and therefore exposure to suboptimal water temperatures would be limited to a small number of individuals. Although this exposure is expected to result in sublethal and lethal effects, some levels of exposure to warmer water temperatures may also be beneficial and a contributing factor influencing rates of anadromy (Sloat and Reeves 2014).

2.5.3.4.2 Clear Creek Flow Releases

Reclamation proposes to release a minimum instream base flow of 200 cfs from October 1 through the end of May and 150 cfs from June through September in Clear Creek, in all water year-types except Critical, when flows may be reduced based on available water from Trinity Reservoir. Additional flows may be required for fall temperature management. Base flows determine the amount of aquatic habitat available for most of the year based on the current channel configuration.

Reclamation also proposes to create (1) spring attraction pulse flows to attract and encourage upstream movement of adult CV spring-run Chinook salmon into Clear Creek, and (2) channel maintenance pulse flows to provide sediment transport and geomorphic benefit. Up to 10 TAF for each type of pulse flow would be available annually. As described in the Appendix C of the ROC on LTO BA, the Clear Creek Implementation Team will provide pulse flow shaping and scheduling recommendations in coordination with Reclamation.

CalSimII is a reservoir-river basin model used to simulate the coordinated operation of the CVP and SWP over a range of hydrologic conditions. CalSimII modeling assumptions included projected climate change, and sea level rise assumptions corresponding to Year 2030. Despite detailed model inputs and assumptions, the CalSimII results differ from real-time operations under stressed water supply conditions. Reclamation proposes to adjust operations when necessary, depending on conditions and constraints, to meet legal and contractual obligations.

Assumptions:

- Modeled runs assumed 200 cfs base flow from October through May, and 10 TAF for spring attraction pulse flows in May and June, in all but Critical water year types. While 150 cfs releases are proposed from June through September (Harrison 2019b), 85 cfs is modeled in July and August in all water year types (Table 2.5.3-4). For this analysis, it was unclear if Reclamation's modeling results showing releases lower than 150 cfs in July and August was an inconsistency resulting from changes from an earlier version of the PA, or if it was a result of competing objectives for CalSimII model inputs. Reclamation clarified that the PA is 150 cfs in July and August (Harrison 2019b), but is not simulated in the model. Therefore, the assumption for this analysis is that the PA is what will occur, and the values in the model for these months are an underestimate, and in error. Under current operations, Clear Creek releases in July and August from 2000-2018 have generally been lower than 150 cfs in most years to conserve cold water pool in Whiskeytown Reservoir for fall water temperature management, except in 2014 and 2015 when base flows higher than 150 cfs were needed to meet water temperature requirements (Figure 2.5.3-9).
- In Critical water year types, the proposed reduction in minimum instream base flows was not quantified. CalSimII modeling results (Table 2.5.3 4) indicate releases would be approximately 40-75 cfs less than proposed base flows. In Critical water year types, the minimum flow releases could be as low 50 cfs from January 1-October 31, and 70 cfs November-December as specified in the MOA under the 1960 minimum flow requirements (amended in 2000 under the Instream Flow Preservation Agreement by and among U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service and California Department of Fish and Game, August 11, 2000), and under the April 15, 2002 SWRCB

- permit. NMFS assumes flows specified in the MOA would be the lowest minimum instream base flow releases that would occur in Critical water year types.
- While the 10 TAF for channel maintenance pulse flows proposed to occur from January through April were not modeled, discussions with Reclamation clarified that this volume of water would not change model outputs significantly (Harrison 2019a).
- While ramping rates during flow decreases of controlled releases from Whiskeytown
 Reservoir were not proposed in the PA, during technical assistance meetings between
 Reclamation and NMFS on May 24, 2019, Reclamation proposed rates of 15-25 cfs per
 hour. This range would decrease stranding risks to juvenile salmonids, and fit within the
 precision of the constraints of the operation of the outlets.

Table 2.5.3-4. Monthly CalSimII outputs for Clear Creek at IGO for the proposed action for all water year-types based on the Sacramento Valley Index (source: ROC on LTO BA, Appendix D, Attachment 3-2, Table 14-2).

	Monthly Flow (CFS)											
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance											7.	
10%	200	200	200	200	200	200	200	277	200	85	85	150
20%	200	200	200	200	200	200	200	277	200	85	85	150
30%	200	200	200	200	200	200	200	277	200	85	85	150
40%	200	200	200	200	200	200	200	277	200	85	85	150
50%	200	200	200	200	200	200	200	277	200	85	85	150
60%	200	200	200	200	200	200	200	277	200	85	85	150
70%	200	200	200	200	200	200	200	277	200	85	85	150
80%	200	200	200	200	200	200	200	277	150	85	85	150
90%	150	150	150	150	150	150	150	237	150	85	85	150
Long Term Full Simulation Period ^a	187	188	190	225	207	194	191	265	181	85	86	148
Water Year Types ^{b,c}												
Wet (32%)	200	200	200	309	249	207	200	277	200	85	85	150
Above Normal (16%)	200	200	200	192	196	196	196	277	200	85	85	150
Below Normal (13%)	195	195	195	195	195	195	195	274	191	85	85	150
Dry (24%)	188	188	188	190	190	190	190	267	183	85	85	150
Critical (15%)	133	141	154	167	167	167	167	214	111	85	94	133

^a Based on the 82-year CalSimII simulation period.

^b As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).

^c These results are displayed with calendar year - year type sorting.

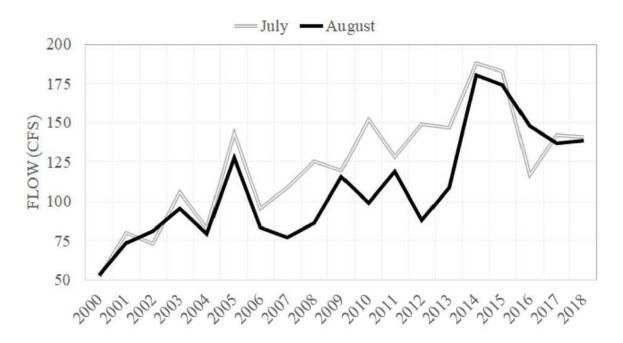


Figure 2.5.3-9. Mean monthly flows [cubic feet per second (cfs)] in July and August at the Igo gaging station (RM 11.0) from 2000-18, Clear Creek, California. Data source: SacPAS: Central Valley Prediction & Assessment of Salmon website (University of Washington Columbia Basin Research 2019).

2.5.3.4.2.1 Minimum Instream Base Flows

Under the PA, minimum instream base flows are 200 cfs from October through May, and 150 cfs from June through September. Increased minimum flows of 150 cfs were first provided in the fall of 1995 for adult fall-run Chinook salmon (Brown 1996) and were based on recommendations for salmon and steelhead summarized in the Clear Creek Fishery study (Department of Water Resources 1986, Newton and Brown 2004). This flow schedule was incorporated into the CVPIA Anadromous Fisheries Restoration Program:

Release 200 cfs October 1 to June 1 from Whiskeytown Dam for spring-, fall-, and late fall-run chinook salmon spawning, egg incubation, emigration, gravel restoration, spring flushing and channel maintenance; release 150 cfs, or less, from July through September to maintain 60°F temperatures in stream sections utilized by spring-run Chinook salmon (U.S. Fish and Wildlife Service 2001).

Reclamation has integrated temperature control and minimum base flow requirements into operations since 1995, which initially led to increased returns of fall-run Chinook salmon. During the summer of 1999, Reclamation first made releases from Whiskeytown Dam to support juvenile steelhead rearing downstream of Saeltzer Dam (prior to its removal in 2000), and increased releases in the fall to reduce water temperatures for CV spring-run Chinook salmon spawning. The proposed minimum instream base flows are the same as what were established in

the NMFS 2009 Opinion, and therefore COS CalSimII modeling outputs and flow conditions under current operations are expected to be similar under the PA.

2.5.3.4.2.1.1 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

Adult CV spring-run Chinook salmon migration into Clear Creek continues during the summer base flow period, with very low rates of passage in July and August (Figure 2.5.3-). From 2013-2016, approximately 35 percent of CV spring-run Chinook salmon passage occurred in June, which also coincided with spring attraction pulse flows. Lowering base flows from 200 cfs to 150 cfs on June 1 would likely create a passage impediment at the confluence due to warm water temperatures, and result in decreased adult migration rates and lower returns of CV spring-run Chinook salmon to Clear Creek.

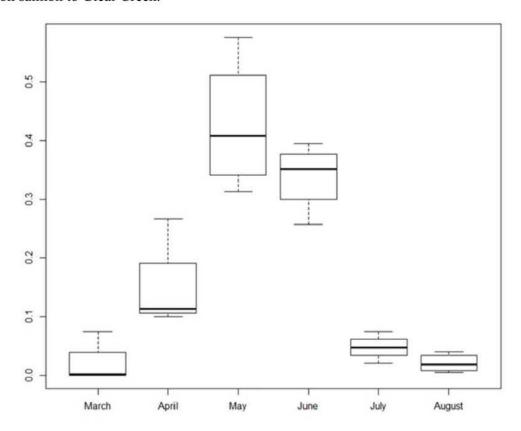


Figure 2.5.3-10. Proportion of annual CV spring-run Chinook salmon passage by month at the Clear Creek Video Station from 2013 to 2016. Pulse flows have occurred all years. Lines in boxes are sample medians, box-ends are upper or lower quartiles, whiskers are minimum and maximum (Clear Creek Technical Team 2018).

The low rate of migration in July and August is likely due to the timing of CV spring-run Chinook salmon in the Upper Sacramento tributaries, and temperature-related migration barriers associated with warmer water at the confluence. While summer base flows would not limit adult holding habitat or passage in the deep pools of canyon reaches, they may restrict upstream

passage from the lower alluvial reaches by creating temperature and low flow barriers at riffles and cascades.

The USFWS has (1) developed rearing and spawning flow-habitat relationship curves for CV spring-run Chinook salmon, CCV steelhead, and fall-run Chinook salmon for Clear Creek; (2) compared habitat available to habitat needed to support population recovery; and (3) provided recommendations for creek flows and habitat needs for a range of population sizes (U.S. Fish and Wildlife Service 2015a). Weighted usable area (WUA) provides a metric of CV spring-run Chinook salmon spawning and rearing habitat availability based on water depth, flow velocity, and substrate.

To estimate spawning and rearing WUA available under the PA, Reclamation performed modeled runs using flow-habitat relationship curves with mean monthly CalSimII flow estimates (Unger 2019). Differences in spawning and rearing WUA in the modeled scenarios and exceedance curves were similar for the PA and COS minimum instream base flows in all water year types. When comparing the PA WUA values to flow-habitat relationships in U.S. Fish and Wildlife Service (2015a), the proposed minimum flows provided adequate rearing habitat for fry and juveniles, but not enough spawning habitat (Figure 2.5.3-1). Low estimates of spawning WUA in the modeled runs are likely due to the use of outdated WUA curves. New WUA curves were developed after gravel supplementation projects increased available spawning habitat in Clear Creek (U.S. Fish and Wildlife Service 2015a). Under the updated curves, the proposed flows provide 50,000-60,000 sq. ft. of WUA. (Figure 2.5.3-).

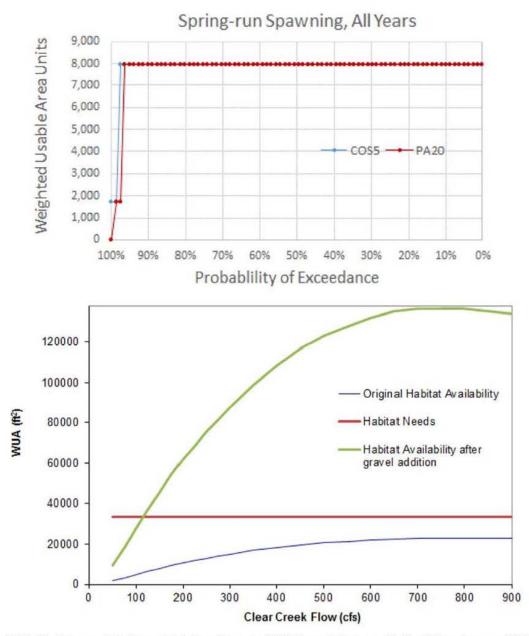


Figure 2.5.3-11. Top graph is the weighted usable area (WUA) modeling results for CV spring-run Chinook salmon spawning habitat in Clear Creek under the proposed action (PA20) (Unger 2019) and current operation scenario (COS5). Bottom graph is the USFWS (2015) WUA curve developed to include the increased spawning habitat availability after gravel addition projects.

In most years under the PA, base flows will need to be greater than 150 cfs after September 15 to provide equal or less than 56°F daily average water temperatures, based on what has occurred under current operations. In Critical year types, base flows may be reduced and 56°F daily

average water temperature may not be achievable, thereby decreasing the amount of available spawning habitat for CV spring-run Chinook salmon. While the WUA analysis does not indicate that spawning habitat is limited given the proposed base flows and current population levels, higher flows generally improve water temperatures for incubating eggs, and increase available spawning habitat. Increased suitable spawning habitat improves reproductive success, especially when larger populations of spawning CV spring-run Chinook salmon are present in Clear Creek.

Since 1999, releases up to 275 cfs have been used to provide equal or less than 56°F daily average water temperatures. Under the PA, after the fall water temperature management period ends, flow releases would be reduced to 200 cfs, or approximately 150 cfs in Critical water year types, exposing CV spring-run Chinook salmon redds to dewatering. Fry emergence typically occurs from mid-November to early February and flow decreases in this period would expose embryos to the effects of dewatering and reduced hyporheic flow. The magnitude of flow change, and therefore, effect, would depend on flows required to meet spawning temperatures in a given year. In an evaluation estimating fall-run Chinook salmon redd dewatering rates in Clear Creek, flow decreases from 275 cfs to 200 cfs dewatered 6.1 percent of redds; 275 cfs to 150 cfs dewatered 29 percent of redds; and 200 cfs to 150 cfs dewatered 11 percent of redds (U.S. Fish and Wildlife Service 2015a). We expect these rates to be similar for CV spring-run Chinook salmon under flow reductions that would occur under the PA. Based on CV spring-run Chinook salmon fry emergence timing in Clear Creek, flow decreases in November and December would affect a high proportion of redds, though a small percentage would become dewatered. Under current operations, Reclamation has not reduced flow releases during the CV spring-run Chinook salmon egg incubation/alevin development period, and NMFS assumes that would continue to be the case under the PA. Based on redd dewatering rates, past operations, and the low occurrence of Critical water year types, reduced egg to fry survival of CV spring-run Chinook salmon is not expected due to flow decreases following the temperature management season.

While the PA base flows provide an adequate amount of suitable habitat based on WUA curves, the flat-lined, steady flow regime may not provide the dynamics needed to create habitat variability that supports diversity of life stages important for survival. Monitoring indicates steady base flows, together with reduced occurrence and magnitude of channel forming flows, have resulted in the stabilization of gravel bars, riparian vegetation encroachment, and decreased habitat complexity in Clear Creek (McBain and Trush 2001, Graham Matthews & Associates 2011). The PA provides some flow variability to improve connectivity and channel processes that improve habitat, create migration cues, and improve downstream passage, which is discussed under the Spring Attraction and Channel Maintenance pulse flow components below.

2.5.3.4.2.1.2 CCV Steelhead Exposure, Response, and Risk

Under the PA component, base flows provide adequate spawning and juvenile rearing habitat for CCV steelhead, based on WUA results (Figure 2.5.3-12) and habitat needs identified in U.S. Fish and Wildlife Service (2015a). This also includes Critical water year types (15 percent of years) when Reclamation will potentially reduce base flows by approximately 50 cfs from October to June (Table 2.5.3-4).

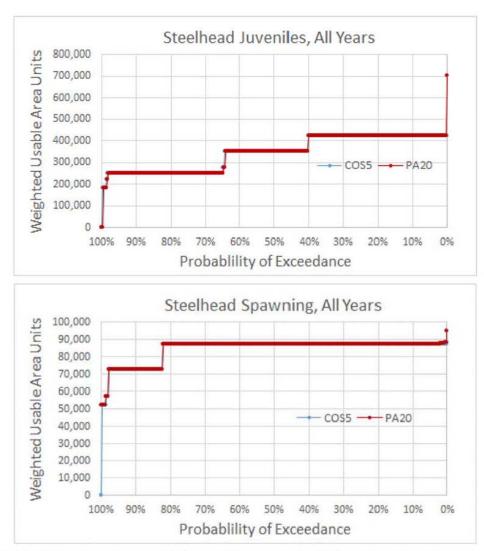


Figure 2.5.3-12. Weighted usable area (WUA) modeling results for CCV steelhead juvenile rearing (top) and spawning habitat (bottom) in Clear Creek under the proposed action (PA20) and current operation scenario (COS5) (Unger 2019).

While the WUA results show adequate habitat, increased water temperatures associated with lowered base flows in Critical water year types and warm air temperatures in the summer may reduce the actual amount of rearing habitat available in the lower watershed. Daily average water temperatures can range from 65°F to 70°F in July and August in the most downstream three miles of the creek, which may restrict the total available habitat for rearing (Figure 2.5.3-5).

In Critical water year types (15 percent of years), base flows may be reduced to approximately 150 cfs during CCV steelhead spawning, and redds may be susceptible to dewatering and egg mortality, depending on when flow decreases occur. Water year type forecasting begins February and type is determined in May. In addition, under current operations, flows greater than 200 cfs have been needed to meet water temperature criterion for CV spring-run Chinook salmon egg incubation though October 31. In those years, flow reductions back to 200 cfs (or less in Critical

water year types) that occur after the onset of CCV steelhead spawning in mid-December would expose redds to dewatering. Any flow reductions from mid-December through April would expose a large portion of CCV steelhead redds to dewatering. In an evaluation estimating fall-run Chinook salmon redd dewatering rates in Clear Creek, flow decreases from 275 cfs to 200 cfs dewatered 6.1 percent of redds; 200 cfs to 150 cfs dewatered 11 percent of redds; and 275 cfs to 150 cfs dewatered 29 percent of redds (USFWS 2015). We expect these rates to be similar for CCV steelhead under flow reductions that would occur under the PA. However, the proportion of CCV steelhead redds dewatered would likely more variable than fall-run Chinook salmon, due to the longer spawning season, and depending on when flow decreases occur. Based on redd dewatering rates, and the low occurrence of Critical water year types, a small amount of reduced egg-to-fry survival of CCV steelhead is expected during minimum base flow decreases.

While an adequate amount of suitable spawning and juvenile rearing habitat is available based on WUA curves, the flat-lined, steady flow regime may not provide the dynamics needed to create habitat variability that supports diversity of life stages essential for survival of CCV steelhead. Steady base flows, together with reduced occurrence and magnitude of channel forming flows has resulted in the stabilization of gravel bars, riparian vegetation encroachment, and decreased habitat complexity in Clear Creek (McBain and Trush 2001, Graham Matthews & Associates 2011). The PA provides some flow variability to improve connectivity and channel processes that improve habitat, create migration cues, and improve downstream passage, which is discussed under the Spring Attraction and Channel Maintenance pulse flow components below.

2.5.3.4.2.2 Spring Attraction Pulse Flows

Reclamation is proposing to allocate 10 TAF to create spring attraction pulse flows, with a daily release up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity). Pulse flows would occur in all water year types, but restricted to a 3-day single event in Critical water year types. The frequency, duration, and timing would be developed by the Clear Creek Implementation Technical Team, as described in Appendix C of the ROC on LTO BA.

The goal of spring attraction flows is to create hydrologic, temperature, and turbidity cues to encourage adult CV spring-run Chinook salmon to Clear Creek from the Sacramento River, and attract them to the furthest upstream habitats for holding and spawning where they can access colder water temperatures, large and remote holding pools, and newly provided, clean spawning gravel. Proposed spring attraction pulse flows may reduce stressors related to water operations by improving flow conditions and water temperature, and increase passage over impediments and improving natural river morphology and function.

Spring attraction pulse flows have been implemented since 2010, and timed to coincide with the CV spring-run Chinook salmon migration period. The Clear Creek Technical team has developed the pulse flow schedule annually using an adaptive approach, by varying the timing, magnitude, and duration of releases based on monitoring results (e.g., Clear Creek Technical Team 2016). Attraction flows are intended to mimic natural hydrologic cues, which include cooler water temperatures and increased turbidity. In years when the adult CV spring-run Chinook salmon population size is large enough to detect, snorkel survey and video monitoring data have shown that pulse flow releases have been successful (Chamberlain 2019a).

2.5.3.4.2.2.1 Spring-Run Chinook Salmon Exposure, Response, and Risk

The proposed spring attraction pulse flows are intended to encourage entry to Clear Creek by coinciding with the adult CV spring-run Chinook salmon migration in Clear Creek, which spans from April through August, and peaks in May and June. Exposure of adult CV spring-run Chinook salmon to pulse flow conditions is dependent on both the timing of scheduled releases and adult returns. Increased flow releases of this magnitude in the spring, when base flows are decreasing and water temperatures are warming, create migration cues for adult CV spring-run Chinook salmon and improve passage conditions by cooling water temperatures, creating turbidity, and increasing passage routes. Improved passage and migratory cues would likely increase numbers of adult CV spring-run Chinook salmon into Clear Creek, and encourage upstream migration to holding pools in the coldest habitat, which would likely increase reproductive success.

Spring attraction pulse flows have been implemented on Clear Creek annually since 2010, and monitoring has indicated some success. Pulse flows events have increased turbidity, decreased water temperatures, and successfully attracted CV spring-run Chinook salmon into Clear Creek at higher rates than the periods without pulse flows in some years (Clear Creek Technical Team 2016, 2018). Monitoring data has shown that a change in distribution upstream of holding CV spring-run Chinook salmon in Clear Creek before and after pulse flows has occurred less frequently (Clear Creek Technical Team 2019). Due to the nature of CV spring-run Chinook salmon in Clear Creek, individuals that migrate in during the pulse flows may stage and hold in the lower reaches rather than migrating upstream, and be susceptible to negative effects from warmer water and introgression with fall-run. Continued implementation of spring attraction flows in the PA in June is expected to provide increased opportunity for adult passage during the lower base flow period.

Spring attraction pulse flows would not occur during CV spring-run Chinook salmon spawning and egg incubation, and therefore, this life stage would not be exposed to the effects of the pulse flows. Rotary screw trap data have shown that 97 percent of juvenile CV spring-run Chinook salmon emigrate as fry, with peak migration in November and December (Earley et al. 2013, Schraml et al. 2018). The remaining cohort rearing in Clear Creek would be exposed to the effects of spring attraction pulse flows annually. Rearing juvenile CV spring-run Chinook salmon have been observed in Clear Creek throughout the spring and summer months during snorkel surveys. While this life history variation appears to represent a small fraction of rotary screw trap passage estimates, these individuals may contribute significantly to the returning adult populations. In the Stanislaus River, outmigrating juvenile Chinook salmon contributed to the returning adult spawning population in different proportion depending on their migratory strategy and flow regime (Sturrock et al. 2015).

Spring attraction pulse flows are expected to benefit juvenile CV spring-run Chinook salmon by improving downstream passage. Pulse flows increase turbidity and velocity, cool water temperatures, and create cues for outmigration. Improved outmigration conditions is expected to reduce stress, disease, predation rates, and thereby improve survival. Pulse flows temporarily provide access to juvenile rearing habitat within floodplains and side channels, which may increase food availability and growth rates. Spring attraction pulse flows may also displace juveniles downstream into warmer water habitat, which may increase risk of predation, disease, and mortality. During spring attraction pulse flow ramp down, juveniles may also become

stranded and isolated from the creek, and succumb to predation or desiccation. Down-ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. However, a low proportion of juveniles are still expected to become stranded or isolated.

Each year during spring attraction pulse flows, we expect benefits to a low proportion of juveniles expected to outmigrate, decreased survival to a low proportion of displaced juveniles that remain in the lower reaches, and decreased survival of a low proportion of juveniles subject to stranding.

2.5.3.4.2.2.2 Sacramento River Winter-run Exposure, Response, and Risk

In some years, video monitoring data have shown winter-run Chinook salmon migrating into Clear Creek during pulse flows (Clear Creek Technical Team 2016). Winter-run adults, carcasses and redds have been observed in Clear Creek during post pulse flow surveys. Pulse flows may attract adult winter-run Chinook salmon into Clear Creek, but spawning in the lower alluvial reaches would likely be unsuccessful due to high rates of temperature-dependent mortality during the summer egg incubation period.

2.5.3.4.2.2.3 CCV Steelhead Exposure, Response, and Risk

Some CCV steelhead embryos would still be incubating from April through June. However, because approximately 90 percent of the annual CCV steelhead redd count occurs by mid-February (Schaefer et al. 2019), a small proportion of the redds would be exposed to scour and fine sediment infiltration, increasing the risk of mortality of incubating embryos. Rearing juvenile CCV steelhead are present throughout Clear Creek during the spring attraction pulse flows. Multiple year classes of juvenile CCV steelhead rear in Clear Creek year round, and are distributed throughout the entire length of the creek. Juvenile CCV steelhead rear in fresh water from 1 to 3 years. Spring attraction pulse flows occur during a time when smolts have been observed outmigrating in Clear Creek. Exposure to pulse flows would give CCV steelhead access to temporary rearing habitat within side channels, potentially increasing food availability resulting in increased growth rates. Increased flows and turbidity and cooler water temperatures create migration cues, improve downstream passage conditions, reduce predation, and increase survival of smolts. Available rearing habitat (WUA) for juvenile CCV steelhead increases from approximately 200,000 sq ft. at base flows to 700,000 sq ft when flows are nearing 900 cfs (U.S. Fish and Wildlife Service 2015a). Though short lived, the pulses may provide opportunity for new food sources, and improved growth and survival. Conversely, juvenile CCV steelhead may be displaced downstream during attraction pulse flows and after flows decrease, remain in unsuitable habitat, which would likely be warmer and at risk of increased predation, disease, and mortality. During spring attraction pulse flow ramp down, juveniles may also become stranded and isolated from the creek, and succumb to predation or desiccation. Down-ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. However, a low proportion of juveniles are still expected to become stranded or isolated. Therefore, we expect increased survival and fitness of a high proportion of CCV steelhead rearing juveniles and outmigrating smolts, in addition to decreased survival to a low proportion of juveniles that remain in the lower reaches after spring-pulse flows. A small proportion of juveniles would also be subject to stranding during the pulse flows.

2.5.3.4.2.3 Channel Maintenance Pulse Flows

Reclamation is proposing to allocate 10 TAF channel maintenance pulse flows each water year, up to the safe release capacity (approximately 900 cfs, depending on reservoir elevation and downstream capacity), except in Dry (24 percent) and Critical (15 percent) water year types. Reclamation will reduce the volume and occurrence of the proposed channel maintenance pulse flows if storm events create natural spills through the Whiskeytown Glory Hole of sufficient duration and magnitude, which include (1) for each storm event that results in a spill of at least 3,000 cfs for 3 days, channel maintenance flow volume for that year or the following year will be reduced by 5,000 acre-feet, and (2) if two spills of at least 3,000 cfs for 3 days each occur, additional channel maintenance pulse flows would not be released that year. Each new water year, channel maintenance pulse flows would not occur until after January 1, such that Reclamation would have enough information to make initial assessments and assumptions of water year type and available storage, and determine what restrictions on occurrence and amount of water may be needed for planning the flows. Given the parameters identified in the PA, NMFS expects that one to four channel maintenance pulse flows would occur from January through April. To maximize the magnitude of the flow and thereby the geomorphic benefit, NMFS also assumes that flows would be scheduled to occur during natural rain events.

The goal of the PA channel maintenance flows is to provide high flow events that will benefit geomorphic processes in the channel and improve salmonid habitat for spawning and rearing. While the magnitude is significantly less than the 3,000-4,000 cfs recommended for sediment transport and floodplain inundation, and the 4,000-6,000 cfs for channel formation (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008), flows would provide some benefit to sediment transport and improving salmonid habitat. In an evaluation of sediment transport in Clear Creek, Graham Matthews & Associates (2013) findings showed that recent spring attraction pulse flows near 1,000 cfs mobilized supplemental spawning gravel (injection gravel), and have had some value for channel maintenance.

Whiskeytown Dam blocks coarse sediment transport, and average annual peak flows and flooding frequency have been reduced downstream of the dam. All but the highest flows that pass as a spill were eliminated. This has led to channel simplification, riparian encroachment, and loss of quality and quantity spawning habitat. High flows are important to form and maintain channel and floodplain morphologies, maintain connectivity, and necessary to sustain previous and current restoration activities, including spawning gravel routing. Injection gravel has been added annually to Clear Creek since 1996 (approximately 176,000 tons) and is dependent on high creek flows for transport downstream. Peak flows resulting from tributary run-off have little effect in the upper 2 miles of the creek so flow releases from Whiskeytown Dam are especially important in this section for injection gravel mobilization (Graham Matthews & Associates 2011).

The controlled operation of flows downstream of Whiskeytown Dam have reduced the frequency of high flows that historically existed, which are necessary to achieve ecological function of Clear Creek. The 2004 Environmental Water Program (EWP) proposal set release targets based on sediment transport modeling, and bed mobility studies that suggested flow magnitudes should range from 4,000 to 6,000 cfs, over two days, at a rate of 3 per 10 years based on the 40-year historical dataset of inflow upstream of the reservoir (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008). Upon further evaluation, it was determined that 3,250 cfs could also

provide significant geomorphic benefit, and this target discharge was used to evaluate the feasibility of the implementation of the reoperation of Whiskeytown Dam to provide flood flows to Clear Creek through the Glory Hole (Reclamation and ESSA 2008).

To determine the frequency of occurrence of the PA channel maintenance flows, NMFS used historic records of Glory Hole spills, and Reclamation's model results for the proportion of Dry and Critical water year types that would occur under the PA. Channel maintenance pulse flows would not occur in approximately 40 percent of years, based on the frequency of occurrence of Dry (24 percent) and Critical (15 percent) water year types. From 1965-2005, there were 13 Glory Hole flow spill events that occurred above 3,250 cfs or greater for one day or more, with gaps of up to 12 years apart (U.S. Bureau of Reclamation and ESSA Technologies Ltd 2008). Based on the historical record, Glory Hole spills of magnitude that would reduce the need for channel maintenance pulse flows would occur in approximately 30 percent of years under the PA. Scheduled channel maintenance pulse flow releases through the outlet would likely occur in approximately 30 percent of years. Therefore, NMFS expects that scheduled channel maintenance pulse flows would occur between 30 to 60 percent of years, depending on the number of uncontrolled spills that occur through the Glory Hole spillway.

In Dry and Critical water year types when channel maintenance pulse flows would not occur, Reclamation proposes to use mechanical methods to mobilize gravel or shape the channel, if needed, to meet biological objectives. Mechanical gravel mobilization or channel re-forming would be based on a plan developed by an interagency team that includes USFWS and NMFS. Frequency, magnitude, and duration would be as needed to mobilize gravel equivalent to the channel maintenance pulse flows proposed in the PA. Mechanical gravel mobilization was not described in the PA in adequate detail in order for NMFS to analyze their effects to species. However, we assume that any mechanical methods would results in additional effects. Likely short-term effects are increased turbidity, and potential injury or mortality of fish if present during in-water work. Therefore, we analyzed this action at the framework level. Once there is sufficient information to provide enough detail in order analyze level of effect, Reclamation would need to consult separately on this action if it is determined additional effects would occur. While mechanical methods may provide some geomorphic benefit, it is unlikely that this benefit will be equivalent to channel maintenance pulse flow releases.

2.5.3.4.2.3.1 CV Spring-Run Chinook Salmon Exposure, Response, and Risk

Based on migration timing data, less than 10 percent of the returning adult CV spring-run Chinook salmon population will be present in Clear Creek during channel maintenance pulse flows and, therefore, exposed to its conditions. High flow and turbidity conditions associated with channel maintenance pulse flows may attract migrating adult CV spring-run Chinook salmon into Clear Creek, if releases occur in March or April. Attraction of earlier arriving adult CV spring-run Chinook salmon to Clear Creek could increase returns, encourage movement to the preferred upstream reaches, and result in a larger spawning population and increased genetic diversity.

Channel maintenance pulse flows are expected provide long-term benefits, improving spawning habitat by mobilizing and dispersing gravel, and reducing fine sediment. During spawning, channel maintenance pulse flows may cause scour or fine sediment infiltration of CV spring-run Chinook salmon redds through early February. The proposed channel maintenance flows (unless

coupled with storm events) are low enough in magnitude, and not likely to cause high rates of redd scour. Temperature based egg-to-fry emergence data, and rotary screw trap monitoring data, have shown the majority of CV spring-run Chinook salmon fry emerge and begin to migrate downstream in November and December in Clear Creek. However, based on temperature-based emergence dates, a low percentage of redds are expected to contain incubating eggs/pre-emergent fry after January 1, and therefore a low proportion are expected to result in mortality in years when channel maintenance pulse flows occur (approximately every 3-6 years; 1-2 times per year).

The majority of juvenile CV spring-run Chinook salmon emigrate by February. Depending on the timing of channel maintenance pulse flows, a low to medium portion of the rearing juveniles are expected to be present. Channel maintenance pulse flows may displace juveniles, make them susceptible to isolation and stranding following down-ramping, and cause mortality. Downramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases. However, a low proportion of juveniles are still expected to become stranded or isolated. High flow releases are expected to benefit juveniles by providing temporary access to additional rearing habitat that provides shelter and access to food, increasing growth and survival. While juvenile CV spring-run Chinook salmon rearing habitat is not limited based on habitat suitability results, at this time of the year, juvenile fall-run Chinook salmon are also present in much larger numbers and compete for rearing habitat. Flows of the proposed magnitude also provide outmigration cues, increased passage routes, and increased protection from predators due to increased turbidity. While the portion of rearing juvenile CV spring-run Chinook salmon is low to medium in years when channel maintenance pulse flows occur (approximately every 3-6 years; 1-4 times per year), channel maintenance flows are expected to provide benefits to rearing and outmigrating juveniles. Additional long term expected benefits of this action to CV spring-run Chinook salmon include increased survival of eggs, and increased production due to improved spawning habitat.

2.5.3.4.2.3.2 CCV Steelhead Exposure, Response, and Risk

Given the timing of the channel maintenance pulse flows contemporaneous with peak storm flows from January through April, and life history of CCV steelhead in Clear Creek, all life stages and the majority of the overall population, including migrating adults, incubating embryos in redds, and rearing and out-migrating juveniles would be exposed to the effects of channel maintenance pulse flows.

Channel maintenance pulses flows would occur during adult CCV steelhead migration and spawning. Because the timing of CCV steelhead migration occurs over a long period, from mid-December through April, and timing may be variable based on in-river conditions, the proportion of passage that occurs after January 1 is variable annually. Based on 5 years of preliminary video monitoring passage data at the mouth of Clear Creek, 24-88 percent (average 46 percent) of steelhead migrate into Clear Creek by January 1. Based on the variability on the timing, frequency and magnitude of channel maintenance pulse flows annually (approximately every 3-6 years; 1-4 times per year), and the range of migration timing, effects to the species migration would be variable each year. For the migration life stage of CCV steelhead, channel maintenance pulse flows would be beneficial, creating cues to encourage migration from the Sacramento River and improve migration conditions by creating more passage routes. Pulse flows would likely help to increase overall population size in Clear Creek.

Channel maintenance pulse flows are expected to improve spawning habitat by mobilizing and dispersing gravel, and reducing fine sediment. CCV steelhead egg incubation occurs from mid-December through June, with peak spawning in January. Redds are located throughout the creek, with the majority distributed downstream of RM 6. Based on spawn timing, the majority of CCV steelhead redds would be exposed to channel maintenance pulse flows, and subject to scour or infiltration of fines that cause mortality to incubating embryos. CCV steelhead may also choose spawning locations at the higher flows, and redds may be dewatered after flow releases are decreased. However, flows of this magnitude normally occurs during CCV steelhead spawning, when winter storms would likely increase creek flows, and therefore the impacts of the channel maintenance pulse flows would not be that different from natural flows. Under most circumstances, approximately 900 cfs would be released, unless it was coupled with flows from a storm event, which are generally not scouring magnitude flows.

Emergent CCV steelhead fry are first observed in the rotary screw traps beginning in mid-January. Juvenile CCV steelhead rear in fresh water from 1 to 3 years, and therefore multiple year classes are present and distributed throughout Clear Creek year round, which includes channel maintenance pulse flow period.

Exposure to channel maintenance pulse flows would give CCV steelhead access to temporary rearing habitat within floodplains and side channels, potentially increasing food availability, resulting in increased growth rates. Flows of the proposed magnitude also provide outmigration cues, increased passage routes, and increased protection from predators due to increased turbidity. Available rearing habitat (WUA) for juvenile CCV steelhead increases from approximately 200,000 sq ft. at base flows to 700,000 sq ft when flows are nearing 900 cfs (U.S. Fish and Wildlife Service 2015a). Though short lived, the channel maintenance pulse flows would allow for some overbank flow to temporarily create side channel and (and potentially floodplain connectivity if releases are coupled with storm flows) and support juvenile growth and survival.

A large proportion of juveniles would be susceptible to stranding and isolation from the creek during down-ramping. However, down-ramping rates will be implemented that reduce stranding risk and minimize negative impacts on survival from flow decreases. A low proportion of juveniles are still expected to become stranded or isolated. The proportion of rearing juvenile CCV steelhead between January and April is high, and in years when they occur (approximately every 3-6 years; 1-4 times per year), channel maintenance flows are expected to provide benefits to rearing juveniles and outmigrating smolts. Additional long term expected benefits of this action to CCV steelhead include increased survival of eggs, and increased production due to improved spawning habitat.

2.5.3.4.2.3.3 Trinity River Division -- Clear Creek Effects Analysis Summary

The effects analysis results suggest that water temperatures will be a high magnitude stressor on Clear Creek CV spring-run Chinook salmon during spawning. Exposure, response, and change in fitness for each action component and life stage are described in Table 2.5.3-5 for CV spring-run Chinook salmon, and 2.5.3-6 for and CCV steelhead.

Table 2.5.3-5. Exposure and summary of responses of Clear Creek CV spring-run Chinook salmon to the proposed action.

Action Component	Life Stage (Location)	Life Stage (Timing)	Stressor	Response	Probable Change in Fitness
Water temperature management: Summer	Adults holding creek-wide	Jun-mid- Sept	Water Temperature	Adults are exposed to >60°F, which may cause stress, disease, reduced fecundity, and prespawn mortality.	Reduced survival and reproductive success.
Water temperature management: Summer	Adults migrating creek-wide	Jun-Aug	Water Temperature; Passage Impediments	Warm water temperatures >65°F may block or inhibit upstream migration.	Reduced survival and reproductive success.
Water temperature management: Summer and Fall	Egg/alevins creek-wide.	Sept-Oct	Water Temperature; Spawning Habitat Availability	Redds are exposed to water temperatures >56°F, resulting in temperature dependent mortality of eggs and embryos. Even meeting the proposed water temperature criterion of 56°F is expected to result in temperature dependent mortality.	Reduced survival and reproductive success.
Water temperature management: Summer	Juveniles/smolts creek-wide.	Jun-Sept	Water Temperature	Temperatures may be >65°F decreasing optimal growth, and increasing stress, risk of predation, and disease.	Reduced growth and survival.
Minimum instream base flows	Adults migrating creek-wide	Jun-Aug	Flow Conditions; Passage Impediments	Low flow barriers at riffles and cascades may inhibit access to holding locations.	Reduced survival and reproductive success.
Minimum instream base flows	Eggs/alevins creek-wide	Nov-Jan	Flow conditions	Base flow reductions in Critical water year types, and/or after the fall water temperature managment period will dewater redds. Eggs and alevins will be exposed to effects of dewatering and reduced hyporheic flow.	Reduced survival.

Action Component	Life Stage (Location)	Life Stage (Timing)	Stressor	Response	Probable Change in Fitness
Spring attraction pulse flows	Adults migrating and holding creek-wide	May-Jun	Flow Conditions; Loss of Natural River Morphology and Function; Passage Impediments/ Barriers	Pulse flows create migration cues, increase turbidity, decrease water temperatures, and improving passage to the most upstream holding locations.	Increased survival and reproductive success.
Spring attraction pulse flows	Juveniles/smolts creek-wide	May-Jun	Flow Conditions; Loss of Natural River Morphology and Function; Passage Impediments/ Barriers	Pulse flows improve downstream passage by creating migration cues, increasing turbidity, and increasing passage routes. High flows provide temporary access to rearing habitat.	Increased growth and life history diversity. Improved survival.
Spring attraction pulse flows	Juveniles/smolts creek-wide	May-Jun	Flow Conditions	Flow decreases following pulse flows cause isolation and stranding. Downramping rates will reduce magnitude of effect.	Reduced survival.
Channel maintenance pulse flows	Adults migrating creek-wide	Mar-Apr	Flow Conditions, Loss of Natural River Morphology and Function, Passage Impediments/ Barriers	Increased flows create migration cues by increasing turbidity, decreasing water temperatures, and improving passage of physical barriers to the most upstream reaches for holding.	Increased reproductive success and survival.
Channel maintenance pulse flows	Juveniles/smolts creek-wide	Jan-Apr	Flow Conditions, Loss of Natural River Morphology and Function, Passage Impediments/ Barriers	Increased flows create migration cues and improve downstream passage by decreasing water temperatures, increasing turbidity and reducing predation risk. Provide temporary access to additional rearing habitat.	Increased growth and life history diversity. Improved survival.
Channel maintenance pulse flows	Juveniles/smolts creek-wide	Jan-Apr	Flow Conditions	Flow decreases following pulse flows cause isolation and stranding. Downramping rates will reduce magnitude of effect.	Reduced survival.

Table 2.5.3-6. Exposure and summary of responses of Clear Creek CCV steelhead to the proposed action.

Action Component	Life Stage (Location)	Life Stage (Timing)	Stressor	Response	Probable Change in Fitness
Water temperature management: summer and fall	Adults migrating/ holding downstream segregation weir	Aug-Oct	Water Temperature	Suboptimal water temperatures >70°F delay migration timing, and >65°F increase stress and susceptibility to disease, leading to reduced fecundity, and increased pre-spawn mortality.	Reduced survival and reproductive success.
Water temperature management: summer	Juveniles/ smolts creek-wide	Jul-Aug	Water Temperature	Suboptimal temperatures >60°F cause stress and reduced growth, and susceptibility to disease and predation, and mortality.	Reduced growth. Reduced survival.
Minimum instream base flows	Eggs/alevins creek-wide	Dec-Mar	Flow Conditions	Base flow reductions in Critical water year types, and/or after the fall water temperature management period ends, will dewater redds. Eggs and alevins will be exposed to effects of dewatering and reduced hyporheic flow.	Reduced survival and reproductive success.
Minimum instream base flows	Juveniles/ smolts creek-wide	Year round	Flow conditions; Loss of Natural River Morphology and Function	Static flow regime restricts access to rearing habitat and refugia, and does not provide migratory cues.	Reduced growth, survival, and life history diversity.
Spring attraction pulse flows	Juveniles/ smolts creek-wide	Apr-Jun	Flow Conditions; Water temperatures; Loss of Natural River Morphology and Function; Passage Impediments/Barriers	Increased flows create migration cues and improve downstream passage by decreasing water temperatures, increasing turbidity. Provide temporary access to additional rearing habitat.	Increased growth, and life history diversity. Improved survival.
Spring attraction pulse flows	Juveniles/ smolts creek-wide	Apr-Jun	Flow Conditions	Flow decreases following pulse flows cause isolation and stranding. Down-ramping rates will reduce magnitude of effect.	Reduced survival.
Channel maintenance pulse flows	Adults migrating/ holding creek-wide	Jan-Apr	Flow Conditions; Loss of Natural River Morphology and Function	Pulse flows create migration cues, increase turbidity, and increase passage routes.	Increased life history diversity. Improved survival.

Action Component	Life Stage (Location)	Life Stage (Timing)	Stressor	Response	Probable Change in Fitness
Channel maintenance pulse flows	Eggs/alevins creek-wide	Jan-Apr	Flow Conditions; Loss of Natural River Morphology and Function	Pulse flows transport sediment that can expose redds to scour and infiltration of fine sediment.	Reduced survival.
Channel maintenance pulse flows	Juveniles/ smolts creek-wide	Jan-Apr	Flow Conditions; Loss of Natural River Morphology and Function	Pulse flows improve downstream passage by creating migration cues, increasing turbidity, and increasing passage routes. High flows provide temporary access to rearing habitat.	Increased growth and life history diversity. Improved survival.
Channel maintenance pulse flows	Juveniles/ smolts creek-wide	Jan-Apr	Flow Conditions	Flow decreases following pulse flows cause isolation and stranding, resulting in mortality. Down-ramping rates will reduce magnitude of effect.	Reduced survival.

2.5.4 American River Division

During consultation for this Opinion, discussions between NMFS and Reclamation resulted in revisions to the PA that were not captured in the February 5, 2019, biological assessment. Unless otherwise stated, Sections 2.5.4.1-2.5.4.5 of the effects description below are based on the modeling associated with the February 5, 2019 PA (Appendix A1, the original PA) and associated modeling that NMFS requested. There were no revisions in the June 14, 2019 PA (Appendix A3) that required supplemental analysis to these sections. The main components of the PA for the American River Division covered in this effects analysis fall into a few major categories: water temperature management, flow management, the Nimbus Fish Hatchery Steelhead Program, and Conservation Measures. Both water temperature management and flow management include several sub-categories. The stressors covered in the main categories are identified in Table 2.5.4-1.

Table 2.5.4-1 Proposed Action Components and Stressors Covered in the American River Division Effects Analysis

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X	-	-	-	-	-	-	-	-	-	~ <u>_</u>	-	ū	-	-	Vimbus Fish Hatchery Steelhead Program Program (2.4.3)
R ≅ S	X	-		Х	X	·75	π.	-	1.73	X	I.E.		(5.	-	Flow Manageme nt (0)
	-	(= 0)	-	-		-	-	-	3=3	-		x	7.5	7-3	Moinimm More Mole Mole Schedule Schedule and Water Temperat or me Standards (5.1.4.2.)
s:=:	X	-	-	-	-	s=:	-	-	-	2 .	-	X	-	-	Water Temperatu or Manageme (1.4.2.1)
Hatchery Effects	Predation	Entrainment	Invasive Species/Food Web Changes	Physical Habitat Alteration	Spawning Habitat Availability	Loss of Tidal Marsh Habitat	Loss of Floodplain Habitat	Loss of Natural River Morphology and Function	Loss of Riparian Habitat and Instream Cover	Flow Conditions	Water Quality	Water Temperature	Harvest/Angling Impacts	Passage Impediments/Barriers	Project Compo nent

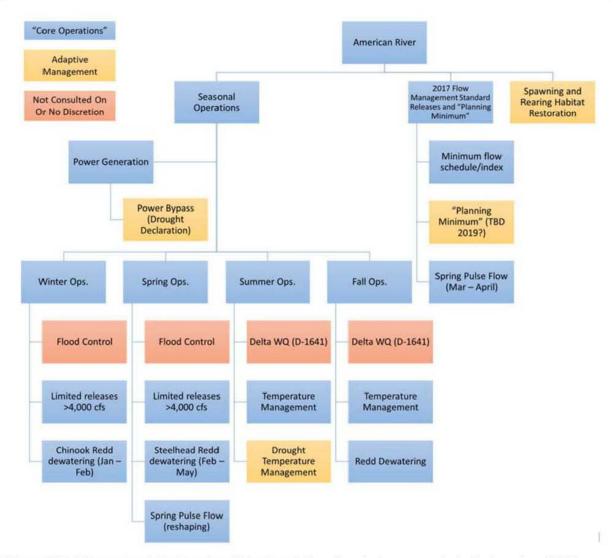


Figure 2.5.4-1 Deconstructed action describing the relation of project components in the American Division

This introduction section is intended to describe how we have deconstructed the PA into stressors that affect CCV steelhead, the only ESA-listed species that spawns within the American River, and describe how we have assessed steelhead exposure and response to PA-related stressors. Naturally-produced CCV steelhead in the lower American River are affected by many different stressors, which, for the purpose of this analysis, are categorized into two groups based on whether they do, or do not, result from CVP operations. The Environmental Baseline section characterizes those stressors which are not the result of CVP operations, although CVP operations may exacerbate the effect of the stressor. An example of a stressor that is exacerbated by CVP operations is predation. Steelhead co-evolved with predators such as pikeminnow (*Ptychocheilus grandis*), but exposure to both elevated water temperatures and limited flow-dependent habitat availability resulting from CVP operations make juvenile steelhead more susceptible to predation (Bratovich et al. 2005, Water Forum 2005).

For the purposes of this analysis, "exposure" is defined as the temporal and spatial co-occurrence of a natural origin steelhead life stage and the stressors associated with the PA. A few steps are involved in assessing steelhead exposure. In the first step, the steelhead life stages and associated timings are identified. Adult steelhead immigration in the American River generally occurs from September through April with a peak occurring from December through March (Surface Water Resources Inc. 2001). Spawning reportedly occurs in late December to early April, with the peak occurring in late February to early March (Hannon and Deason 2008). The embryo incubation life stage begins with the onset of spawning in late December and generally extends through May, although, in some years incubation can occur into June (Surface Water Resources Inc. 2001). Juvenile steelhead typically rear in the American River for a year or more before emigrating as smolts from January through June (Surface Water Resources Inc. 2001).

The second step in assessing steelhead exposure is to identify the spatial distribution of each life stage. The steelhead immigration life stage occurs throughout the entire lower American River with adults holding from approximately RM 5 to Nimbus Dam at RM 23 (Hannon and Deason 2008). Approximately 90 percent of spawning occurs upstream of the Watt Avenue Bridge area located at about RM 9.4 (Hannon and Deason 2008). The juvenile life stage occurs throughout the entire river, with rearing generally occurring in the vicinity of the upstream areas used for spawning. Most juvenile steelhead are believed to migrate through the lower sections of the American River into the Sacramento River as smolts.

The last step in assessing steelhead exposure is to overlay the temporal and spatial distributions of PA-related stressors on top of the temporal and spatial distributions of lower American River steelhead. This overlay represents the completed exposure analysis and is described in the first three columns of Table 2.5.4-3. Unless otherwise specified in Table 2.5.4-3, the temporal and spatial distributions of PA-related stressors are the same as the temporal and spatial distributions of steelhead life stages as specified in Table 2.5.4-3.

Now that the exposure of lower American River steelhead to the PA has been described, the next step is to assess how these fish are likely to respond to the PA-related stressors. In general, responses to stressors fall on a continuum from slight behavioral modifications to certain death. Life stage-specific responses to specific stressors related to the PA are described in detail in the following sections and are summarized in Table 2.5.4-3. There may be other project stressors acting on lower American River steelhead than those identified in Table 2.5.4-3. However, this effects analysis intends to identify and describe the most important project-related stressors to these fish. The stressors from the project components were identified based on a comprehensive literature review, which included the following documents:

- Lower American River State of the River Report (Water Forum 2005);
- Aquatic Resources of the Lower American River: Baseline Report (Surface Water Resources Inc. 2001);
- Impacts on the Lower American River Salmonids and Recommendations Associated with Folsom Reservoir Operations To Meet Delta Water Quality Objectives and Demands (Bratovich et al. 2005);
- American River Steelhead Spawning 2001 2007 (Hannon and Deason 2008);
- Steelhead Restoration and Management Plan for California (McEwan and Jackson 1996);
- Evaluation of Effects of Flow Fluctuations on the Anadromous Fish Populations in the Lower American River (Snider et al. 2001);

- NMFS 2009 Opinion (National Marine Fisheries Service 2009b); and
- ROC on LTO BA (U.S. Bureau of Reclamation 2019)

2.5.4.1 Lower American River Water Temperature Management

Releases from Nimbus Dam to the American River affect the quantity and quality of steelhead habitat (Snider et al. 2001, Water Forum 2005), water quality, and water temperature (State Water Resources Control Board 1999, Kimmerer and Nobriga 2008). Water temperature is perhaps the physical factor with the greatest influence on American River steelhead. Water temperature directly affects survival, growth rates, distribution, and developmental rates. Water temperature also indirectly affects growth rates, disease incidence, predation, and long-term survival (Myrick and Cech Jr 2001). Water temperatures in the lower American River are a function of the timing, volume, and temperature of water being released from Folsom and Nimbus dams, river distance, and environmental heat flux (Bartholow 2000). Thus, water temperatures in the lower American River are influenced by PA operations. Indirectly, water temperatures in the lower American River can be influenced by the effect of precipitation patterns and climate on storage volume and water temperatures in Folsom Reservoir.

This analysis relies on both modeled water temperature results and recent water temperature data. As for other Division analyses, NMFS used modeled temperatures provided in the BA to evaluate the suitability of water temperature conditions for salmonids under the PA. Recent water temperature data from the lower American River are used to provide context for temperature scenarios that steelhead could be exposed to under the PA. Recent water temperature data from the lower American River are assumed to be in the same general range water temperatures as those expected to occur under the PA, and may be a better indicator of the daily temperature patterns that steelhead will be exposed to under the PA than the modeled water temperature results, which have a monthly time-step.

Embryo Incubation

Myrick and Cech Jr (2001) examined the effects of water temperature on steelhead (and Chinook salmon) with a specific focus on Central Valley populations and reported that steelhead egg survival declines as water temperature increases past 50°F. In a summary of technical literature examining the physiological effects of temperature on anadromous salmonids in the Pacific Northwest, U.S. Environmental Protection Agency (2001) reported that steelhead egg and alevin survival would decline with exposure to constant water temperatures above 53.6°F. Rombough (1988) as cited in (2001) found less than four percent embryonic mortality of steelhead incubated at 42.8, 48.2, and 53.6°F, but noted an increase to 15 percent mortality at 59°F. In this same study, alevin mortality was less than five percent at all temperatures tested, but alevins hatching at 59°F were considerably smaller and appeared less well developed than those incubated at the lower test temperatures.

In a laboratory study examining survival and development of steelhead eggs incubated at either 46.4°F or 64.4°F, Turner et al. (2007) found that eggs incubated at the higher temperature experienced higher mortality, with 100 percent mortality of eggs from one of three treatments at the higher temperature. Also, those fish incubated at the higher temperature that did survive exhibited greater structural asymmetry than fish incubated at the lower temperature. Similar to Turner et al. (2007), Myrick and Cech Jr (2001) reported an increase in physical deformities in steelhead that were incubated at higher water temperatures. Structural asymmetry has been

negatively correlated with fitness in rainbow trout (Leary et al. 1984). Overall, the literature indicates that steelhead egg mortality increases at and above a range of 54°F to 57°F (Myrick and Cech Jr 2001, U.S. Environmental Protection Agency 2001, Bratovich et al. 2012).

Given that the literature results are from laboratory studies, steelhead eggs incubating in the redds in the river may need even colder temperatures than 54°F to have high survival. Martin et al. (2017) found strong evidence that significant thermal mortality occurred during the embryonic stage in Chinook salmon in some years due to a >5°F reduction in thermal tolerance in the field compared to laboratory studies. Martin et al. (2017) used a biophysical model of oxygen supply and demand to demonstrate that such discrepancies in thermal tolerance could arise to differences in oxygen supply in lab and field contexts. Because oxygen diffuses slowly in water, as embryos consume oxygen they deplete the concentration of oxygen in the surrounding water, reducing their rate of oxygen supply. This is exacerbated in warm waters because oxygen demand increases exponentially with temperature. Flowing water replenishes oxygen through convective transfer, and thereby increases oxygen supply. Thus, higher flows deliver more oxygen to embryos than low flows allowing for higher thermal tolerance. The Chinook salmon egg survival temperature relationships found in laboratory studies likely overestimate thermal tolerance of eggs developing in the river by roughly 3°C because those studies typically take place at relatively high flows compared to flows experienced by eggs in spawning gravels in the river (Martin et al. 2017). This issue likely applies to what is known about the relationship between thermal tolerance and steelhead survival given that, like Chinook salmon, steelhead eggs incubate under the water column in spawning gravels. The limits of thermal tolerance are set by oxygen supply and demand. As steelhead eggs are smaller than Chinook salmon eggs, it may be expected that their oxygen needs are lower. However, a study using brown trout (Salmo trutta) and Atlantic salmon (S. salar) eggs found that oxygen consumption increases relatively slowly with increasing egg mass (Einum et al. 2002). Therefore, the effects of increased water temperature associated with decreased oxygen supply are expected to be similar for steelhead eggs and Chinook salmon eggs.

Based on the thermal relationships reported above and the temporal distribution of steelhead egg incubation (*i.e.*, late December through May), some level of egg mortality and/or reduced fitness of those individuals that survive is expected with exposure to the water temperatures that are expected to occur with implementation of the PA. For example, mean water temperatures at Watt Avenue from 1999 through 2018 ranged from about 48°F to over 55°F in March, 50°F to over 60°F in April, and 54°F to over 65°F in May (Figure 2.5.4-2). Those data indicate that steelhead egg mortality is expected to occur for at least a small proportion of the population in most years during April and May under the PA.

Higher egg mortality and increased fitness consequences would occur for steelhead eggs and alevins that were spawned later in the spawning season (e.g., spawned in March or April rather than January). This selective pressure towards earlier spawning and incubation under the PA would continue to constrain the temporal distribution of spawning, resulting in a decrease in population diversity, and consequently a likely decrease in abundance.

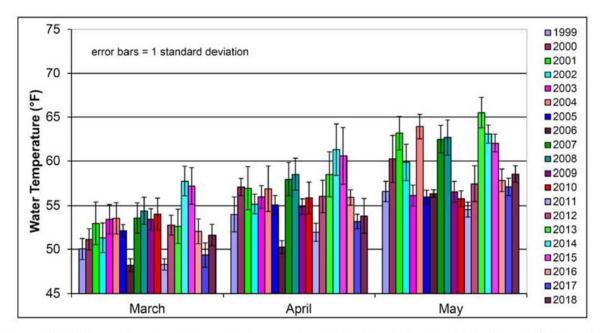


Figure 2.5.4-2 Lower American River water temperature during March, April, and May from 1999 through 2018 represented as the mean of the daily average at the Watt Avenue gage (Original data were obtained from the CDEC website.)

Modeled water temperatures also demonstrate that steelhead eggs will be exposed to stressful conditions with implementation of the PA. Exceedance plots of water temperatures below Nimbus Dam are expected to be over 54°F for about 60 and 100 percent of the cumulative water temperature distribution during April and May, respectively; water temperatures are expected to be above 57°F for about 10 percent of the distribution in April and 70 percent in May (Figure 2.5.4-3 and Figure 2.5.4-4). The frequency of temperatures above 56°F has been reduced in the PA modeling as compared to the COS. During the warmest 20 percent of the cumulative water temperature distribution during May, water temperatures are expected to exceed 62°F in both the PA and COS modeling.

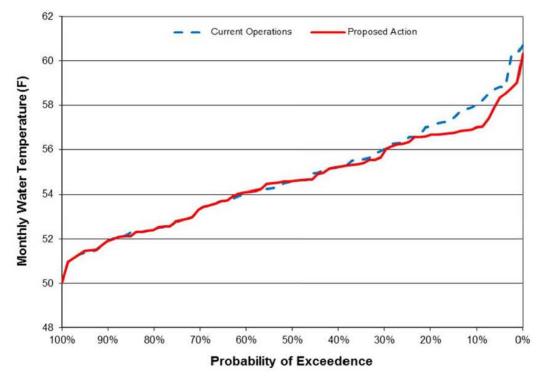


Figure 2.5.4-3 Exceedance plot of modeled water temperatures in the lower American River directly below Nimbus Dam during April (HEC-5Q Temperature Model results, 2019).

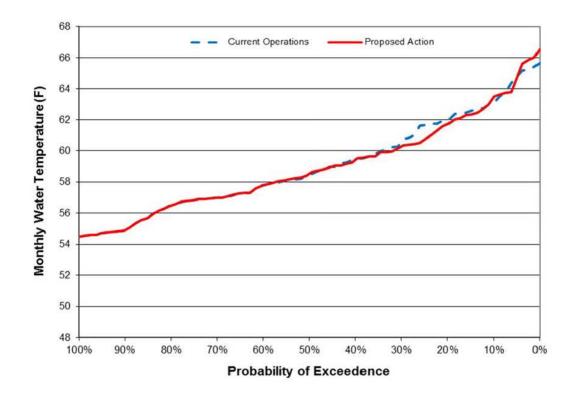
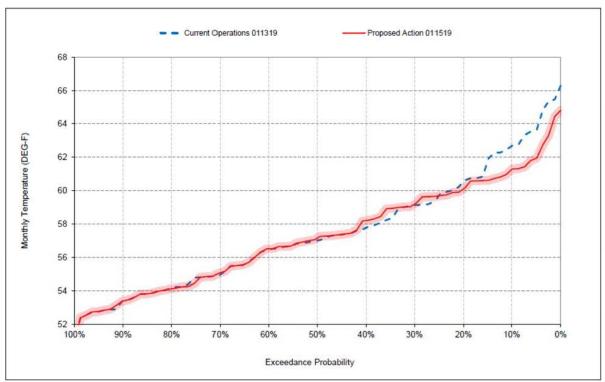


Figure 2.5.4-4 Exceedance plot of modeled water temperatures in the lower American River directly below Nimbus Dam during May (HEC-5Q Temperature Model results, 2019).

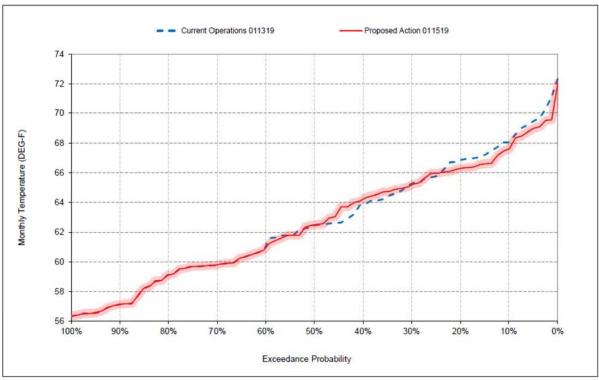
Water temperatures at or above the 54°F to 57°F range during the steelhead egg incubation period would occur more frequently downstream than at Nimbus Dam, as shown in the April and May exceedance plots at Watt Avenue (Figure 2.5.4-5 and Figure 2.5.4-6). Water temperatures exceeding 57°F occur about 50 percent of the years in April (Figure 2.5.4-5) and 90 percent of the years in May (Figure 2.5.4-6) under the PA. The frequency of temperatures at Watt Ave above 60°F in April and 66°F in May are reduced under the PA. The frequency of temperatures between 57°F to 60°F in April and between 62°F and 66°F in May have slight increases under the PA as compared to the COS.



^{*}All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

Figure 2.5.4-5 Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during April (HEC-5Q Temperature Model results, 2019).

^{*}These are draft results meant for qualitative analysis and are subject to revision.



^{*}All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

Figure 2.5.4-6 Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during May (HEC-5Q Temperature Model results, 2019).

2.5.4.1.1 Juvenile Rearing

Water temperatures in the lower American River often reach and exceed levels that are stressful to juvenile rearing steelhead, particularly during the summer and early fall. Assessing the response of American River steelhead juveniles to water temperatures is challenging due partly to a historical paucity of published primary literature (Myrick and Cech 2004). Though there has been a recent increase in studies and modeling of growth and anadromy patterns using temperature as a variable (Satterthwaite et al. 2010, Sogard et al. 2012, Beakes et al. 2014), there remains a fairly substantial knowledge gap in relation to the effects of temperature on juvenile CCV steelhead.

The available information suggests that American River steelhead may be more tolerant to high temperatures than steelhead from regions further north (Myrick and Cech 2004). Cech Jr and Myrick (1999) reported that when American River steelhead were fed to satiation at constant temperatures of 51.8°F, 59.0°F, and 66.2°F, growth rates increased with temperature, whereas Wurtsbaugh and Davis (1977) found that maximal growth of juvenile steelhead from North Santiam River in Oregon occurred at a cooler temperature (*i.e.*, 62.6°F). Furthermore, Beakes et al. (2014) found that steelhead sourced from Coleman National Fish Hatchery and reared at 68°F maintained an average growth rate above 0.6 mm/day, but only when a daily food ration equal to 6 percent of the total wet fish biomass was fed. All of these studies were conducted in a

^{*}These are draft results meant for qualitative analysis and are subject to revision.

controlled laboratory setting with unlimited, or relatively high, food availability. Under more variable conditions, such as those experienced in the wild, the effect of water temperature on juvenile steelhead growth would likely be different. For example, the above Beakes et al. (2014) study found that treatments of high water temperature and low rations resulted in the lowest growth rate. Additionally, a field study conducted between 2006 and 2009 estimated that average summer and fall growth of juvenile steelhead in the American River ranged from 0.98 to 1.12 mm/day despite maximum summer temperatures regularly exceeding 68°F (Sogard et al. 2012). This rate of growth is unusually high for CV salmonids and exceeds growth rates obtained by fish rearing on managed floodplains in the CCV (e.g., Katz et al. 2017). Sogard et al. (2012) postulate that this rate of accelerated growth is likely the result of low steelhead density and high food availability, which further illustrates the interactive role of water temperature and food availability in modulating growth in salmonids (Manhard et al. 2018).

Even with this tolerance for warmer water temperatures, steelhead in the lower American River exhibit symptoms of thermal stress. Elevated water temperatures can increase physiological stress and subsequently, decrease immune system function. For example, the occurrence of a bacterial-caused inflammation of the anal vent (commonly referred to as "rosy anus") of American River steelhead has been reported by CDFW (formerly CDFG) to be associated with warm water temperatures (Figure 2.5.4-7). Sampling in the summer of 2004 showed that this vent inflammation was prevalent in steelhead throughout the river and the frequency of its occurrence increased as the duration of exposure to water temperatures over 65°F increased. At one site, the frequency of occurrence of the anal vent inflammation increased from about 10 percent in August, to about 42 percent in September, and finally up to about 66 percent in October (Bratovich et al. 2005).



Figure 2.5.4-7 Anal vent inflammation in a juvenile steelhead from the American River (Bratovich et al. 2005).

The juvenile steelhead immune system properly functions up to about 60°F, and then is dramatically compromised as water temperatures increase into the upper 60°Fs (Bratovich et al. 2005). CDFW reports that, in 2004, the anal vent inflammation occurred when juvenile steelhead were exposed to water temperatures above 65°F (Bratovich et al. 2005). From 1999 through 2018, daily mean water temperatures during the summer at Watt Avenue were most often above 65°F, and during 2001, 2002, 2004, 2007, 2008, 2013, 2014, 2015, and 2016 water temperatures were often over 68°F (Figure 2.5.4-8). CDFW has suggested that these observations are associated with the debilitation of the steelhead's immune system responses (Bratovich et al. 2005); they, therefore may be indicative of an increased susceptibility to and decreased ability to deal with disease, which would decrease fitness.

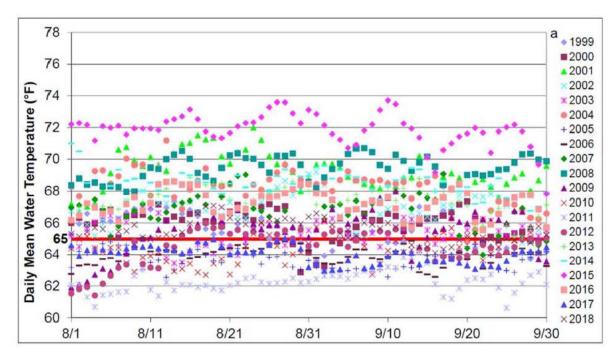


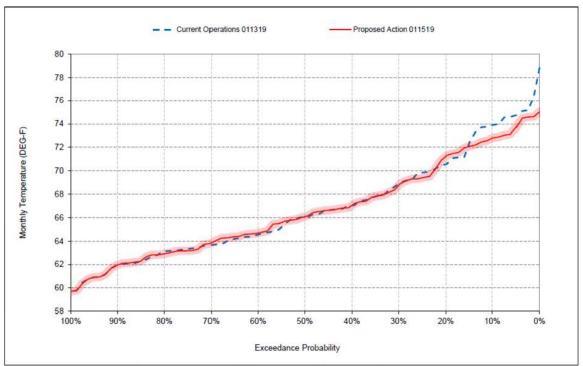
Figure 2.5.4-8 Lower American River water temperature during August and September from 1999 through 2018 represented as the daily mean at the Watt Avenue gage. The 65°F line is indicated in red because visible symptoms of thermal stress in juvenile steelhead are associated with exposure to daily mean water temperatures above 65°F. Data were provided by Reclamation.

Based on water temperature modeling results presented in the ROC on LTO BA, water temperatures associated with visible symptoms of thermal stress in juvenile steelhead (i.e., >65°F) are expected to occur from June through September under both the PA and COS. Exceedance plots of monthly water temperatures at Watt Avenue show that temperatures are expected to be at or above 65°F for about 58 percent of the cumulative distribution in June (Figure 2.5.4-9), 100 percent in July (Figure 2.5.4-10), and about 95 percent of August (Figure 2.5.4-11) under both PA and COS. In September, model results show that 65°F will be exceeded 93 percent of the time under the COS and 96 percent of the time under the PA (Figure 2.5.4-12). Additionally, historic data between 1999 and 2018 show that on average only 43 percent of days from July through September are amenable to steelhead rearing using a temperature metric of 65°F; that number increases to 80 percent using a temperature metric of 68°F (Figure 2.5.4-13).

When reviewing historic data, NMFS assumes potential climate change scenarios (+1°F and +3°F applied to historical water temperatures), would further reduce the temperature suitability of the lower American River for Steelhead with less than 30 percent of days able to meet a 65°F temperature metric.

In the exceedance plots of monthly water temperatures (Figure 2.5.4-9 through Figure 2.5.4-12), the PA shows some improvements over COS at high temperatures, but the modeling results do not reflect the yet to be determined planning minimum carryover storage target intended to improve water temperatures. While the modeling includes a "soft" goal to maintain a minimum end-of-September storage of 275 thousand acre feet (TAF), this was partially intended to conceptually emulate the undefined end-of-December planning level minimum that (according to a meeting from Reclamation on May 31st) is expected to land between 200 TAF and 300 TAF. According to Reclamation in a meeting on May 31, 2019, Reclamation explained that the current planning level minimum is 200 TAF and has been used historically for seasonal planning. Reclamation intends to share the final planning level minimum with NMFS along with the expected actions that the water users intend to take to improve storage conditions in years when the planning level minimum cannot be met solely by flexibility in CVP operations. Based on Reclamation's understanding of the expected performance from the planning level minimum, the CalSim modeling is the best representation of the PA. While the planning level minimum is not explicitly modeled, the increase from the existing planning level minimum is expected to improve storage conditions in certain years and help to protect the storage gains from the decreases in the minimum required releases in the PA as compared to the COS.

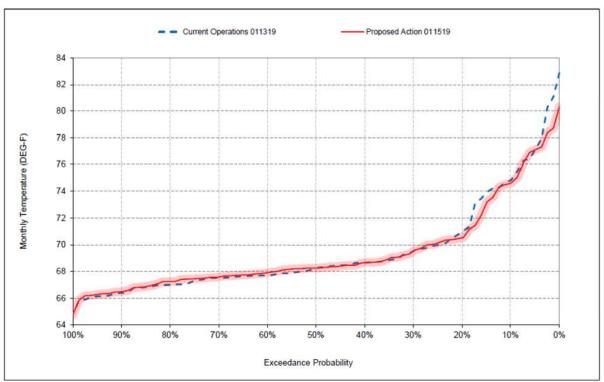
Despite best efforts, lower American River water temperatures have not improved over at least the last 20 years. Although the PA, when compared to the COS, shows reductions in the frequency of the highest temperatures, the resulting temperatures are not assumed to solve the thermal challenges in the lower American River as the BA does on pages 5-196 and 5-197 (Appendix A1): "The implementation of the proposed 2017 FMS measures under the proposed action would provide suitable habitat conditions in the lower American River for CV Steelhead, particularly during drought conditions and improve conditions for this life stage." The BA does not include information supporting the notion that the lower American River habitat will be thermally suitable during drought.



^{*}All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

Figure 2.5.4-9 Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during June (HEC-5Q Temperature Model results, 2019).

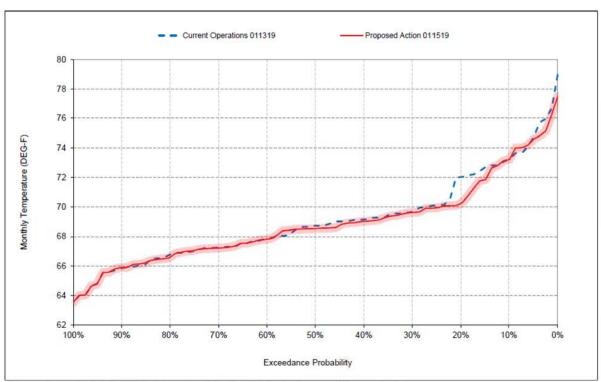
^{*}These are draft results meant for qualitative analysis and are subject to revision.



^{*}All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

Figure 2.5.4-10 Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during July (HEC-5Q Temperature Model results, 2019).

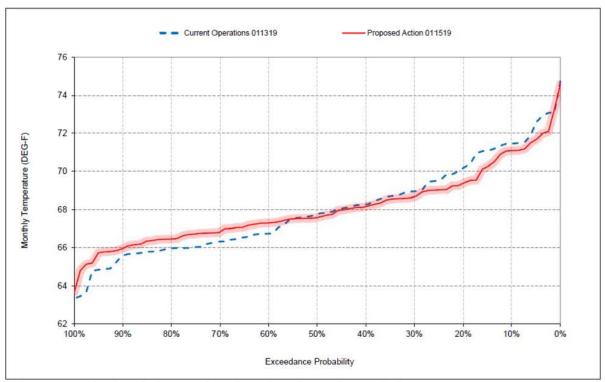
^{*}These are draft results meant for qualitative analysis and are subject to revision.



^{*}All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

Figure 2.5.4-11 Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during August (HEC-5Q Temperature Model results, 2019).

^{*}These are draft results meant for qualitative analysis and are subject to revision.



^{*}All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

Figure 2.5.4-12 Exceedance plots of modeled water temperatures in the lower American River near Watt Avenue during September (HEC-5Q Temperature Model results, 2019).

^{*}These are draft results meant for qualitative analysis and are subject to revision.

Table 2.5.4-2 Percent of days with temperatures in the lower American River amenable to steelhead rearing under historic and potential climate change conditions (Data were obtained from the CDEC webpage).

Percent Days with Lower American River Temperature Amenable to Steelhead Rearing

(65°F or 68°F) in Key July through September Period Under Historic (+0°F) or Climate Change (+1°F / 3°F) Scenarios

		68°F Metri			
Year	+0°F	+1°F	+3°F		
1999	100%	97%	59%		
2000	100%	91%	32%		
2001	38%	20%	8%		
2002	93%	71%	32%		
2003	100%	100%	43%		
2004	50%	30%	5%		
2005	100%	100%	100%		
2006	100%	100%	100%		
2007	92%	65%	22%		
2008	18%	5%	0%		
2009	100%	97%	39%		
2010	100%	100%	85%		
2011	100%	100%	100%		
2012	100%	100%	71%		
2013	77%	49%	16%		
2014	33%	5%	0%		
2015	2%	0%	0%		
2016	88%	62%	15%		
2017	100%	100%	100%		
2018	100%	99%	32%		
verage	80%	70%	43%		

	65°F Metri	10000
+0°F	+1°F	+3°F
59%	32%	9%
32%	21%	2%
8%	7%	5%
32%	17%	7%
43%	14%	0%
5%	1%	1%
100%	74%	0%
100%	67%	9%
22%	13%	0%
0%	0%	0%
39%	30%	13%
85%	55%	13%
100%	99%	61%
71%	36%	9%
16%	13%	0%
0%	0%	0%
0%	0%	0%
15%	12%	7%
100%	59%	5%
32%	7%	0%
43%	28%	7%

Lower American River Temperature Suitability for Steelhead Rearing Decreases With Anticipated Climate Warming

Comparing Historic Daily Average Temperatures (Green) with Potential Climate Change Increases of +1°F (Yellow) +3°F (Red) overlaid with 65°F / 68°F temperature ranges (Black Horizontal Dashes) from May 15 - Oct 31 for Juvenile Steelhead Over-Summer Rearing at Watt Ave Bridge

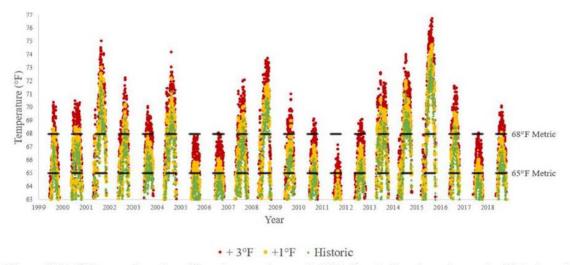


Figure 2.5.4-13 Lower American River temperature suitability for steelhead rearing under historic and potential climate change conditions (Data were obtained from the CDEC webpage).

As described in Water Forum (2005), Folsom Reservoir is commonly operated to meet water quality objectives and demands in the Delta. These operations limit coldwater pool availability in Folsom Reservoir, thereby potentially resulting in elevated water temperatures in the lower American River, which likely results in increased predation rates on juvenile rearing steelhead. According to CDFW (2005 op. cit. Bratovich et al. 2005), water temperatures above 65°F are associated with a large (*i.e.*, 30-40 species) complex warmwater fish community, including highly piscivorous fishes such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and Sacramento pikeminnow. Juvenile rearing steelhead may be exposed to increased predation due to both increased predator abundance and increased digestion and consumption rates of these predators associated with higher water temperature (Vigg and Burley 1991, Vigg et al. 1991).

Some striped bass reportedly reside in the lower American River year-round, although their abundance greatly increases in the spring and early summer as they migrate into the river at roughly the same time that steelhead are both emerging from spawning gravels as vulnerable fry and migrating out of the river as smolts (Surface Water Resources Inc. 2001). Striped bass are opportunistic feeders, and almost any fish or invertebrate occupying the same habitat eventually appears in their diet (Moyle 2002). Empirical data examining the effect of striped bass predation on steelhead in the lower American River have not been collected, although one such study was conducted in the Delta (California Department of Water Resources 2008). Results of this study concluded that steelhead of smolt size had a mortality rate within Clifton Court Forebay that ranged from 78 ± 4 percent to 82 ± 3 percent over the various replicates of the study. The primary source of mortality to these steelhead is believed to be predation by striped bass.

Although Clifton Court Forebay and the lower American River are dramatically different systems, this study does demonstrate that striped bass are effective predators of steelhead. Considering that striped bass are abundant in the lower American River during the spring and early summer (Surface Water Resources Inc. 2001), when much of the steelhead initial rearing and smolt emigration life stages are occurring, striped bass predation on juvenile steelhead is considered to be an important stressor to this population. Although the predation stressor by striped bass is also considered in the baseline, the decrease in water temperatures and continued low flows that exist in both the COS and the PA are unlikely to reduce the magnitude of this stressor. As described in the Section 2.5.4.2.3 below, low releases from Nimbus Dam force juvenile steelhead into areas that provide less cover from predation. The PA shows less frequent low flows. The model results show that, under the PA, American River flow below Nimbus is less than 500 cfs once in July, twice in August, and twice in September in the whole 82 year (984 month) simulation period. Under the COS, however, this occurs more frequently: one occurrence in October, 3 occurrences in (each of the following months) January, February, April, May, June, August, and 4 occurrences in (each of the following months) March, July, and September.

Overall, the PA includes some improvement (reduction) in water temperature but direct sublethal impacts and indirect lethal impacts (predation) for a high proportion of the American River steelhead population in nearly all years is still expected, supporting a high magnitude classification for this stressor.

2.5.4.1.2 Smolt Emigration

To successfully complete the parr-smolt transformation, a physiological and morphological adaptation to life in saline water, smolting steelhead require cooler water temperatures than for the rearing life stage. Adams et al. (1975) reported that steelhead undergo the smolt transformation when reared in water temperatures below 52.3°F, but not at warmer water temperatures. In a report focusing on the thermal requirements of Central Valley salmonids, Myrick and Cech Jr (2001) came to a similar conclusion stating that steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range. Others have suggested that water temperatures up to about 54°F will allow for successful steelhead smoltification (Zaugg et al. 1972, Wedemeyer et al. 1980, U.S. Environmental Protection Agency 2001).

Steelhead smolt emigration in the lower American River occurs from January through June (Surface Water Resources Inc. 2001). Monitoring data from 1999 through 2018 showed that lower American River water temperatures frequently exceeded 52°F by March and exceeded 54°F in all but 5 years by April (Figure 2.5.4-2). Based on the thermal requirements for steelhead smolts described above, it could be hypothesized that smolt transformation is likely inhibited by exposure to lower American River water temperatures. However, recent research has shown that most steelhead in the lower American River express an anadromous life history (Satterthwaite et al. 2010, Sogard et al. 2012). Their results support the conclusion that the majority of juvenile steelhead undergo smolt transformation and emigrate as they reach age 1 (Satterthwaite et al. 2010, Sogard et al. 2012). However, Sogard et al. (2012) caution that this early emigration may be associated with high water temperatures in the lower American River and that "there may be negative aspects that were not addressed in [their] study, such as disease or reduced thermal tolerance of older juveniles." It remains uncertain how increased warming associated with climate change will impact successful transformation of parr to smolts in the lower American River.

Reclamation's modeled water temperatures demonstrate that the PA is expected to result in similar conditions to the COS that will inhibit the successful transformation from parr to smolts. For example, exceedance plots show that water temperatures at Watt Avenue will be warmer than 54°F for 83 percent of the years in April (Figure 2.5.4-5) under both the COS and the PA scenarios. In May water temperatures are expected to exceed 58°F in 85 percent of the years (Figure 2.5.4-6) and in June modeling results suggest that they will always be over 58°F under both the COS and the PA (Figure 2.5.4-9). These data suggest that smolts are expected to experience sublethal thermal impacts under both the COS and the PA for at least the small proportion of steelhead emigrating in April, May, and June.

2.5.4.1.3 Minimum Flow Schedule and Water Temperature Standards

Reclamation proposes to adopt the minimum flow schedule and approach proposed by the Water Forum in 2017¹² and highlights a new planning minimum process. The ROC on LTO PA (Appendix A1) states that:

"Reclamation proposes to work together with the American River water agencies to define an appropriate amount of storage in Folsom Reservoir that represents the lower bound for typical forecasting processes at the end of calendar year (the "planning minimum"). The planning minimum brings Reclamation's forecasting process together with potential local actions that either increase Folsom storage or reduce demand out of Folsom Reservoir. The implementation of a planning minimum allows Reclamation to work with the American River Group to identify conditions when local water actions may be necessary to ensure storage is adequate for diversion from the municipal water intake at Folsom Dam and/or the extreme hydrology presents a risk that needs to be properly communicated to the public and surrounding communities. This planning minimum will be a single value (or potentially a series of values for different hydrologic year types) to be used for each year's forecasting process into the future. The objective of incorporating the planning minimum into the forecasting process is to provide releases of salmonid-suitable temperatures to the lower American River and reliable deliveries (using the existing water supply intakes and conveyance systems) to American River water agencies that are dependent on deliveries or releases from Folsom Reservoir. This planning minimum is expected to be initially defined in 2019; however, it will be continuously evaluated between Reclamation and the Water Forum throughout implementation."

Based on the modelling information provided in the ROC on LTO BA, the temperature standard of 65°F described in the ROC on LTO PA cannot always be met. According to the PA, the temperature management planning process will aim to attain the best possible temperature schedule for the compliance point at Watt Avenue Bridge. In conditions when the target temperature can not be met, higher temperatures will be targeted to most efficiently use the available coldwater pool. Reclamation states that the draft temperature management plan will be shared with the American River Group before finalization, where NMFS assumes Reclamation will receive input on potential higher temperatures due to limited coldwater pool availability. The PA states the following:

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¹² The BA refers a 2017 proposal, however the subject document provided to NMFS by Reclamation is dated December 2018 and has the title of: Lower American River – Standards for Minimum Flows.

- "Reclamation proposes to manage the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F (or other temperature as determined by the temperature modeling) or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile Steelhead rearing in the lower American River."
- "During the May 15 to October 31 period, if the Temperature Plan defined temperature requirement cannot be met because of limited cold water availability in Folsom Reservoir, then the target daily average water temperature at Watt Avenue may be increased incrementally (i.e., no more than 1°F every 12 hours) to as high as 68°F. The priority for use of the lowest water temperature control shutters at Folsom Dam shall be to achieve the water temperature requirement for listed species (i.e., Steelhead), and thereafter may also be used to provide cold water for Fall-Run Chinook Salmon spawning."

Modeling of both the PA and the COS provided in the ROC on LTO PA indicate 65°F will be regularly exceeded. NMFS assumes that this exceedance will occur under the implementation of the PA due to similar constraints under the COS. These include:

- (1) operational (e.g., Folsom Reservoir operations to meet Delta water quality objectives and demands and deliveries to M&I users in Sacramento County) and structural (e.g., limited reservoir water storage and coldwater pool) factors limit the availability of coldwater for water temperature management;
- (2) despite careful planning and the annual development of a water temperature management plan, in most years since the late 1990s, Reclamation has not achieved the temperatures (NMFS 2009 Opinion and analysis of recent temperatures presented in this Opinion);
- (3) climate change impacts are expected to continue, which will likely further constrain lower American River water temperature management.

A comparison of north-of-Delta deliveries to CVP M&I contractors, which are mostly in the American River Basin, using CalSim II modeling, shows that the COS and PA values are relatively similar in most year-types, with slightly higher deliveries being made in BN WYTs under the PA compared to the COS. This slight increase is supported by Table 5-3 in the ROC on LTO BA (Appendix D, Attachment 3-1), which shows decreases in Folsom Lake storage in BN WYTs under the PA compared to the COS. It is worth noting that the temperature standards do not include the steelhead embryo incubation or smolt emigration life stages, even though lower American River water temperatures during those life stages often reach and exceed levels that result in sublethal effects and increased mortality (see Sections 0 Embryo Incubation and 2.5.4.1.2 Smolt Emigration).

2.5.4.1.4 Conservation Measure - Water Temperature Management During Drought

Reclamation proposes the following conservation measure in the ROC on LTO PA (Appendix A1) that involves temperature management in the American River:

"Drought Temperature Management: In severe or worse droughts, Reclamation proposes to evaluate and implement alternative shutter configurations at Folsom Dam to allow temperature flexibility."

The level of detail provided in ROC on LTO PA on this measure is not sufficient to determine the level of potential effect on CCV steelhead. Based on conversations with Reclamation in May 2019, NMFS understands that this action refers to a practice known as "deganging" the current temperature shutters to allow a more efficient use of the available coldwater pool. Deganging may be more efficient owing to the increased ability to fine tune release temperatures via the increased number of potential shutter configurations. The benefits of this action for future drought years has not been modeled but is expected to allow for longer use of the warmer water in the reservoir and reserve cooler water for later in the temperature management season. Historically, this operation has only occurred once, in 2015. We assume the conservation measure may continue to minimize temperature-related impacts to CCV steelhead in a more efficient matter than annual temperature shutter operations.

2.5.4.1.5 Magnitude of Water Temperature as a Stressor to American River Steelhead

This effects analysis indicates that the thermal impacts on lower American River steelhead expected to occur with implementation of the PA will be similar to the impacts associated with the recent past operations of the American River Division of the CVP. Water temperature under the PA is considered a high to medium magnitude stressor based on the exposure of multiple steelhead life stages to lethal and sublethal conditions in all but the wettest and coldest years, and without structural modifications to Folsom Dam, this stressor would continue.

2.5.4.2 Lower American River Flow Management

2.5.4.2.1 Flood Control and Delta Water Quality (D-1641)

Releases from Folsom Reservoir, are made, in part, for flood control and to meet Delta water quality objectives and demands. These operations can result in release events during the winter and spring that are characterized by rapid flow increases for a period of time followed by rapid flow decreases. Releases from Folsom Dam are re-regulated approximately 7 miles downstream by Nimbus Dam. A few examples of these types of flow fluctuations can be seen in the Nimbus Dam release pattern, which occurred in 2004 (Figure 2.5.4-14). Reclamation operates for flood control in accordance with the 2019 Water Control Manual. The PA does not propose changes to flood control operations from the current water control manual and therefore, these impacts from passing high flow events would be consistent between the COS and the PA.

Reclamation and the U.S. Army Corps of Engineers constructed a new spillway (completed in 2017), known as the Joint Federal Project (JFP), which allows Reclamation to make releases for flood control at lower elevations than the original spillway, but at significantly higher elevations than the River Outlet Tubes. Use of the JFP allows for more stable high flows during storm events by allowing lower release volumes to occur sooner and have a longer duration but with lowered peak flow. Additionally, the use of the JFP should improve the cold water pool volume by avoiding releases thru the River Outlet Tubes which draw from a colder elevation. The Water Control Manual that accompanies this new facility has undergone separate ESA consultation with the Corps as the federal action agency (National Marine Fisheries Service 2018e), and analyses and terms and conditions in that Opinion are in the baseline for this consultation. The

operation under the new Water Control Manual with the new spillway is expected to result in decreases of peak flows with potential longer durations of flood releases to evacuate the same volume when compared to historical operations. For this reason, using historical data for flood control is not appropriate.

2.5.4.2.2 Flow Fluctuations

Flow fluctuations in the lower American River have been documented to result in steelhead redd dewatering and isolation (Hannon et al. 2003, Water Forum 2005, Hannon and Deason 2008). Redd dewatering can affect salmonid embryos and alevins by impairing development and causing direct mortality due to desiccation, insufficient oxygen levels, waste metabolite toxicity, and thermal stress (Becker et al. 1982, Reiser and White 1983). Isolation of redds in side channels can result in direct mortalities due to these factors, as well as starvation and predation of emergent fry. Hannon et al. (2003) reported that five steelhead redds were dewatered and 10 steelhead redds were isolated in a backwater pool at the lower Sunrise side channel when Nimbus Dam releases were decreased on February 27, 2003. When releases were decreased on March 17, 2003, seven steelhead redds were dewatered and five additional redds were isolated from flowing water at the lower Sunrise side channel. In April 2004 at the lower Sunrise side channel, five steelhead redds were dewatered and "many" redds were isolated (Bratovich et al. 2005). Redd dewatering at Sailor Bar and Nimbus Basin occurred in 2006, with most of the redds being identified as Chinook salmon redds, at least one was positively identified as a steelhead redd, and several more redds were of unknown origin (Hannon and Deason 2008) (Figure 2.5.4-15).

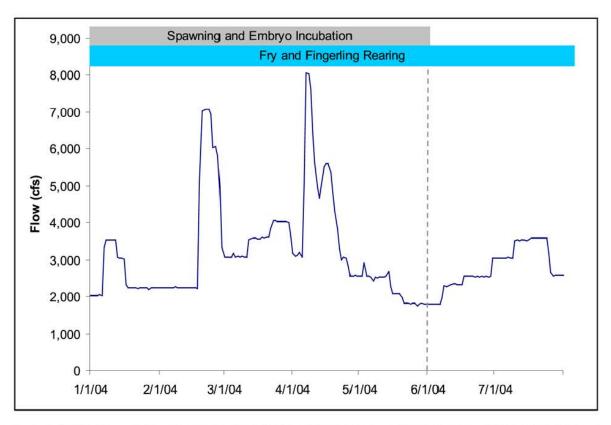


Figure 2.5.4-14 Mean daily release rates from Nimbus Dam in January through July of 2004. The timing of the steelhead life stages that are most vulnerable to flow fluctuations during these months are displayed.

Although reports of steelhead redd dewatering and isolation in the lower American River are limited to 2003, 2004, and 2006, these effects have likely occurred in other years because: (1) the pattern of high releases followed by lower releases which occurred during the steelhead spawning period (*i.e.*, primarily January through March) in 2003, 2004, and 2006, is similar to the pattern observed during the spawning period in many other years [CDEC data (http://cdec.water/ca/gov/) from 1994 through 2019]; and (2) monitoring was not conducted during many release events and, consequently, impacts were not documented. Impacts associated with flow fluctuations are expected to continue to occur with implementation of the PA through 2030 because operations that would address this stressor (i.e., ramping rates) were not described in the PA.

Juvenile steelhead isolation has also been reported to occur in the lower American River. For example, Bratovich et al. (2005) reported that juvenile steelhead became isolated from the river channel in both 2003 and 2004 following a flow increase and decrease event associated with meeting Delta water quality objectives and demands. Isolated fish are exposed to warm water temperatures and fish and avian predation within habitats that are disconnected from the river, likely increasing their mortality risk. If the isolated habitat is not reconnected to the river with a subsequent increase in river stage, all steelhead in that habitat are assumed to die.

Flow fluctuations in the American River under the PA are expected to impact a small proportion of steelhead eggs and juveniles with a medium annual frequency, supporting a medium stressor magnitude classification for both life stages.

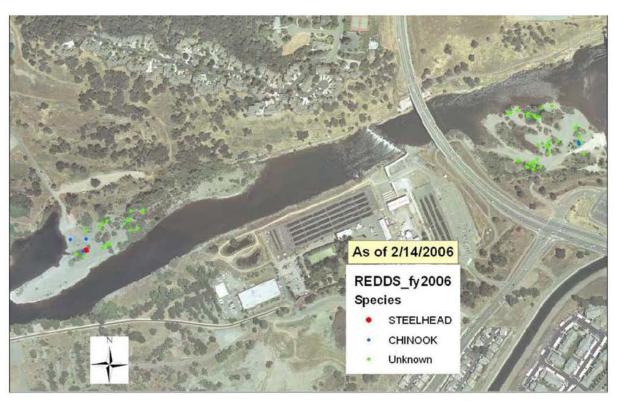


Figure 2.5.4-15 Dewatered redds at Nimbus Basin and Sailor Bar, February 2006 (figure was modified from Hannon and Deason 2008).

2.5.4.2.3 Low Flows

In addition to flow fluctuations, low flows also can negatively affect lower American River steelhead. Yearling steelhead are found in bar complex and side channel areas characterized by habitat complexity in the form of velocity shelters, hydraulic roughness elements, and other forms of cover (Surface Water Resources Inc. 2001). At low flow levels, the availability of these habitat types becomes limited, forcing juvenile steelhead densities to increase in areas that provide less cover from predation. With high densities in areas of relatively reduced habitat quality, juvenile steelhead become more susceptible to predation as well as disease. Low flows are included in both the PA and the COS; however, the PA shows less frequent low flows. The model results show that, under the PA, American River flow below Nimbus is less than 500 cfs once in July, twice in August, and twice in September in the whole 82 year (984 month) simulation period. Under the COS, however, this occurs more frequently: one occurrence in October, 3 occurrences in (each of the following months) January, February, April, May, June, August, and 4 occurrences in (each of the following months) March, July, and September. Periodic exposure of a small proportion of American River juvenile steelhead to these low flow

conditions is expected during implementation of the PA through 2030, although less frequently than under the COS.

2.5.4.2.4 2017 Flow Management Standard Releases and "Planning Minimum"

See Section 2.5.4.1.3 Minimum Flow Schedule and Water Temperature Standards

2.5.4.2.5 Spawning Habitat Availability

Modeling results show that flows under the PA provide slightly lower steelhead spawning habitat for about 10 percent of years, relative to current operations, but otherwise the PA matches the COS (Figure 2.5.4-16).

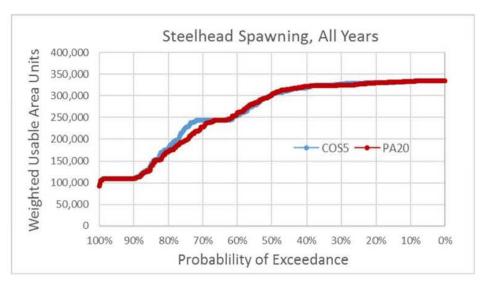


Figure 2.5.4-16 Steelhead Spawning Habitat Availability under the Proposed Action (PA20) and under Current Operations (COS5) over all Water Year Types. Results provided by Reclamation.

2.5.4.2.6 Magnitude of Flow Management as a Stressor to American River Steelhead

This effects analysis indicates that the flow-related impacts on lower American River steelhead expected to occur with implementation of the PA will be similar to the impacts associated with the recent past operations of the American River Division of the CVP. Flow management under the PA is considered a medium magnitude stressor based on the expected periodic occurrence of lethal and sublethal impacts resulting from redd dewatering, fry stranding, and juvenile isolation.

2.5.4.3 Nimbus Fish Hatchery Steelhead Program

The PA includes operation of the Nimbus Fish Hatchery Steelhead Program. The ROC on LTO BA states, "Reclamation has ongoing activities that would continue, including fish hatchery programs at Coleman and Nimbus, because these facilities were intended as mitigation for the construction of CVP dams." However, the ROC on LTO BA provides no information regarding how the Nimbus Hatchery Steelhead Program will be operated.

Generally speaking, effects range from beneficial to negative for programs that use local fish for hatchery broodstock and from negligible to negative when a program does not use local fish for broodstock. Hatchery programs can benefit population viability but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co-occurrence and effects that potentially disadvantage fish from natural populations.

Nimbus Fish Hatchery on the American River has been a substantial producer of steelhead in the Central Valley since 1955 (Leitritz 1970) and, during the first several decades of operation, broodstock was imported periodically from coastal steelhead populations, including the Eel, Mad and Russian rivers (Lee and Chilton 2007). The effects of this out-of-basin stocking are apparent in both individual and population analyses, in which the Nimbus Fish Hatchery and American River populations are intermediate between the coastal steelhead populations and all other Central Valley populations (Pearse and Garza 2015). Notably, the closest relationship of the American River populations outside of the Central Valley is to fish from Northern California, in the group that includes the Eel and Mad rivers, rather than to more geographically proximate populations in San Francisco Bay.

For this reason, the Nimbus Fish Hatchery stock is not currently part of the CCV steelhead DPS, and its impacts to the natural American River population include both genetic and behavioral effects (Myers et al. 2004). As described in Pearsons et al. (2007), the selective pressures in hatcheries are dramatically different than in the natural environment, which can result in genetic differences between hatchery and wild fish (Weber and Fausch 2003) and subsequently differences in behavior (Metcalfe et al. 2003).

The continued use of out-of-basin (Eel River/Mad River) broodstock is concerning, particularly for Central Valley populations that not geographically proximate to the American River. According to Pearse and Garza (2015), "The clustering of other Central Valley below-barrier populations with Nimbus and American River samples, particularly those from the Calaveras and Tuolumne Rivers, indicates that introgression of natural populations by fish with coastal steelhead ancestry has occurred through straying/migration of Nimbus Hatchery steelhead." This issue has been perpetuated by the long-time practice of releasing hatchery steelhead production far downstream from the hatchery (e.g., at Discovery Park which is adjacent to the confluence with the Sacramento River; ~river mile 0), which contributes to adult returns straying to nonnatal rivers and creeks thereby spreading out-of-basin genetics throughout the Central Valley. The California Hatchery Scientific Review Group made the following comments about these practices (California Hatchery Scientific Review Group 2012):

"There is evidence that Nimbus Hatchery steelhead may stray throughout the Central Valley and spawn naturally in other streams where hatcheries are not present. Both juvenile releases and hatchery strays from Nimbus have the potential to affect naturally spawning steelhead in other watersheds."

"Although this is intended to be a segregated program, genetic evidence confirms that Eel River genes are throughout the Sacramento System."

"The current broodstock for this program should be replaced with an alternative broodstock that is appropriate for the American River."

"Investigate straying rates for Jibboom release site (Discovery Park). We do not consider a release site 21 miles downstream of the hatchery to be an on-station release. Transporting and releasing juveniles to areas outside of the American River or to the lower American River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the American River from the confluence of the Sacramento River as possible to reduce adult straying and increase the number of adults returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate on-site releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery."

The Nimbus Fish Hatchery Steelhead Program has been working to address these concerns.

Regarding the release site concern, in recent years, juvenile CCV steelhead from Nimbus Fish Hatchery have been released at locations further upstream than Discovery Park. In March 2019, all of the steelhead production from Nimbus Fish Hatchery was released at the Sunrise location (~RM 20). This location is just a few miles downstream from the hatchery and is expected to minimize straying, relative to the Discovery Park location.

Assuming 100 percent of the steelhead production continues to be released at the Sunrise location, the Nimbus Fish Hatchery Steelhead Program is considered a stressor of medium magnitude. However, if the release location shifts back to Discovery Park or further downstream (Bay-Delta), then the program would be considered a high magnitude stressor, given the known genetic impacts to steelhead throughout the Sacramento River basin associated with the use of Eel River origin broodstock at Nimbus Fish Hatchery.

2.5.4.4 Conservation Measures

2.5.4.4.1 Spawning and Rearing Habitat Restoration

In ROC on LTO BA, Reclamation states "conservation measures include non-flow actions that benefit listed species without impacting water supply or other beneficial uses."

"Spawning and Rearing Habitat Named Projects: Pursuant to CVPIA 3406(b)(13), Reclamation proposes to implement the Cordova Creek Phase II and Carmichael Creek Restoration projects, and increase woody material in the American River. Reclamation also proposes to conduct gravel augmentation and floodplain work at: Paradise Beach, Howe Ave, Howe Avenue to Watt Avenue, William Pond Outlet, Upper River Bend, Ancil Hoffman, Sacramento Bar—North, El Manto, Sacramento Bar—South, Lower Sunrise,

Sunrise, Upper Sunrise, Lower Sailor Bar, Nimbus main channel and side channel, Discovery Park, and Sunrise Stranding Reduction."

"Reclamation proposes to continue maintenance activities at Nimbus Basin, Upper Sailor Bar, and River Bend restoration sites."

The effects of these conservation actions are part of the environmental baseline because they previously have undergone ESA section 7 consultation either through individual or programmatic actions. Similarly, any past restoration activities that were completed under the NMFS 2009 Opinion are also considered part of the environmental baseline. The above restoration actions have been consulted on previously such that their past and future beneficial effects to increased spawning and rearing habitat for listed salmonids are factored into the environmental baseline. Reclamation proposes to continue supporting this program into the future. As a result, at the framework-level, we expect continued benefits to CCV steelhead, including increased production and growth and survival.

2.5.4.4.2 Nimbus Fish Hatchery Hatchery Genetics Management Plan

The April 30, 2019, track changes version of the ROC on LTO PA (Appendix A2) states that "Reclamation will complete a Hatchery Genetic Management Plan (HGMP) for steelhead and a Hatchery Management Plan for Fall-run Chinook Salmon as part of Nimbus Fish Hatchery management. Reclamation will work with CDFW and NMFS to establish clear goals, appropriate time horizons, and reasonable cost estimates for this effort."

In order to provide enough certainty regarding how and when the PA component would be implemented, and to assess its effects, the HGMP will need to be developed further. Generally, an HGMP would be expected to have beneficial effects by improving the genetic management of steelhead within the Nimbus Fish Hatchery and decreasing the potential negative effects of environmental conditions and water operations. These general beneficial effects are included in this analysis of effects in this Opinion at the framework level.

2.5.4.5 American River Division Effects Analysis Summary

The effects analysis results suggest that water temperature will be a high magnitude stressor on American River steelhead, flow management will be a medium stressor on American River steelhead, and operation of the Nimbus Fish Hatchery Steelhead Program will be a medium or high magnitude stressor on the population (and DPS), depending on the hatchery production release location. Based on the responses of steelhead exposed to the PA described above and summarized in Table 2.5.4-3, fitness consequences to individuals include reduced survival during embryo incubation, reduced survival and growth during juvenile rearing, reduced survival during smolt emigration, and reduced genetic integrity.

Table 2.5.4-3 Exposure and summary of responses of American River steelhead to the proposed action.

Ties Cissal	T the Ctane Timing	Ctunnou	Danaura	D L. Ll. Etta. D. Justian
Location	Life Stage Tilling	DH ESSUI	мезропос	1 1 Obabie Tilliess Reduction
Spawning	Late-Dec early	Folsom/Nimbus releases – flow	Redd dewatering and isolation	Reduced reproductive success
Primarily upstream	Api	пистанон	spawning spawning	
of Watt Ave. area				
Spawning	Late-Dec early	Nimbus Hatchery – hatchery O.	Reduced genetic integrity. Garza et	Reduced genetic integrity
	Apr.	mykiss spawning with natural-	al. (2008) showed that genetic	
Primarily upstream of Watt Ave. area		origin steelhead	samples from the population spawning in the river and the	
			hatchery population were "extremely	
			similar" and both exhibiting Eel River steelhead genetic.	
Embryo incubation	Late-Dec - May	Water temperatures warmer than	Sublethal effects - reduced early life	Reduced survival
Primarily upstream	į	life stage requirements, particularly occurring upstream of Watt Ave. in	stage viability; direct mortality; restriction of life history diversity	
of Watt Ave. area		April and May	(i.e., directional selection against	
			May)	
Embryo incubation	Late-Dec May	Folsom/Nimbus releases – flow fluctuations	Redd dewatering and isolation. Hannon et al. (2003) reported that 5	Reduced survival
Primarily upstream			steelhead redds were dewatered and	
of Watt Ave. area			10 steelhead redds were isolated at	
			Nimbus Dam releases were	
			decreased on February 27, 2003.	
			When releases were decreased on	
			March 17, 2003, seven steelhead	
			redds were dewatered and five	
			flowing mater at the lower Suprice	
			side channel In April 2004 at the	
			lower Sunrise side channel, five	
			steelhead redds were dewatered and	
			"many" redds were isolated	
			(Bratovich et al. 2005). Redd	
			dewatering at Sailor Bar and Nimbus	

Life Stage/	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
			Basin occurred in 2006 (Hannon and Deason 2008).	
Juvenile rearing	Year-round	Folsom/Nimbus releases – flow fluctuations; low flows.	Fry stranding and juvenile isolation; low flows limiting the availability of	Reduced survival
Primarily upstream		particularly during late summer	quality rearing habitat including	
of Watt Ave. area		and early fall	predator refuge habitat	
Juvenile rearing	Year-round	Water temperatures warmer than	Physiological effects - increased	Reduced growth; Reduced
of Watt Ave. area		occurring upstream of Watt Ave.	vent inflammation) and predation.	survival
100		during June through September	Visible symptoms of thermal stress	
			in juvenile steelhead are associated	
			with exposure to daily mean water	
			temperatures above 65°F (Bratovich	
			et al. 2005). From 1999 through	
			during the summer at Watt Avenue	
			were most often above 65°F, and	
			during 2001, 2002, 2004, 2007, 2008,	
			2015, 2014, 2015, and 2016 water	
			temperatures were often over 68°F	
			(Figure 2.5.4-8). Modeled long-term	
			Avenue from June through	
			September under the proposed	
			Project (including 2025 climate	
			change simulation) range from	
			approximately 66°F to 70°F (ROC on LTO BA).	
Smolt emigration	Jan Jun.	Water temperatures warmer than	Physiological effects - reduced	Reduced growth;
Throughout entire		occurring downstream of Watt	ability to successfully complete the smoltification process increased	Reduced survival
river		Ave. during March through June	susceptibility to predation	

2.5.5 Bay-Delta Division

During consultation for this Opinion, discussions between NMFS and Reclamation resulted in revisions to the PA that were not captured in the February 5, 2019, BA. Unless otherwise noted, Sections 2.5.5.1-2.5.2.10 of the effects description below are based on the modeling associated with the February 5, 2019 PA (Appendix A1, the original PA) and associated modeling that NMFS requested. Section 2.5.5.11 provides a supplemental effects analysis to assess the effects of the June 14, 2019 PA revisions reflected in the final PA (Appendix A3), including a discussion of whether and how the PA revisions modify the effects analyzed in Sections 2.5.5.1-2.5.5.10.

Numerous stressors continue to affect the viability of salmonid populations. Table 2.5.5-1 provides a summary of which stressors from the "Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead" (National Marine Fisheries Service 2014b) will be analyzed under each PA component within this effects analysis for the Bay-Delta Division.

Table 2.5.5-1. Summary of primary stressors influenced by each Proposed Action component for the Bay/Delta Division. Primary stressors are from the NMFS 2014 Recovery Plan for Central Valley Salmonids, and NMFS 2018 Recovery Plan for sDPS of Green Sturgeon. An "X" indicates the stressor will be analyzed for at least one life-stage and species and a "-" indicates that the stressor is

not applicable for	a	particular	Proposed	Action	com	ponent.
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		_											_	_	$\overline{}$
Project Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
2.5.6.3 Delta Cross Channel	х	1	1	_	х	-	-	4	-		12 16	3443	X	х	120
2.5.6.4 North Bay Aqueduct	120	i i	-	_	х	10	-	<u>3</u> ≟@	82	10	127)	320	X	х	20
2.5.6.5 Contra Costa Water District – Rock Slough Diversion		•	•	-	х	-	5	150	-		Ð	75)	х	х	5 8
2.5.6.6 Water Transfers	X20	- 1	X	Х	х	re	-	028	824	. 31	20	3(2)	X	х	-20
2.5.6.7 Suisun Marsh	Х	÷	5	=/	-	15	ä	-		300			X	х	3/
2.5.6.8 South Delta Export Operations		1	1	-	X		-	(#)		3	#:	(4)	X	х	-

rs pacts pacts pacts and print point pacts pact pacts pact pacts pact pacts pact pacts pact pacts pact	
Passage Impediments/Barriers Harvest/Angling Impacts Water Temperature Water Quality Flow Conditions Loss of Riparian Habitat and Instream Cover Morphology and Function Loss of Floodplain Habitat Loss of Tidal Marsh Habitat Spawning Habitat Availability Physical Habitat Availability Physical Changes Entrainment Predation	Hatchery Effects
2.5.6.8.3.1 South Delta Salvage and Entrainment X X X X	*
2.5.6.8.4.1.1 Integrated Early Water Pulse X X - Protection Turbidity Event	-
2.5.6.8.4.1.2 Salmonid Onset X X - Trigger	-
2.5.6.8.4.2 End of OMR Management X X X X	()
2.5.6.8.4.3 Additional Real- time OMR Management X X X X	a
2.5.6.8.4.4 Storm Related OMR Flexibility X X X X	*
2.5.6.8.5.1 Minimum Export X X X Rate	*
2.5.6.8.5.2.1 Predator Removal (CO ₂ Injection)	340
2.5.6.8.5.2.2 Tracy Fish Collection Facility X Release Sites Improvements	*
2.5.6.8.5.3.1 Predator Removal from Clifton Court Forebay - PRES X X X	1
2.5.6.8.5.3.2	-
2.5.6.8.5.3.3 X - X	20

Project Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
Aquatic Weed Control for Predator Habitat															
2.5.6.8.5.3.4 Operational Changes when Listed Fish are Present	2	3	-	4 7	x	122	-	19 0	16 2 0	ų.	9 8	:24	X	x	<u> </u>
2.5.6.8.5.3.5 Clifton Court Forebay Aquatic Weed and Algal Bloom Control	ii.	1	-	X	31	100		臣	£.	16	E.	E.	8 <u>2</u> 5	x	4
2.5.6.9 South Delta Agricultural Barriers	х	· · · · · · · · · · · · · · · · · · ·	х	X	X	•	-			500	8.	х	X	х	•
2.5.6.10.1.1.1.1 Fall Delta Smelt Habitat	355		X	X	X	X 	-	. =)	-	*	#:	(#)		-	i n si
2.5.6.10.1.1.2 San Joaquin Basin Steelhead Telemetry Study	3	37	SEC.		-	SE	ž	30	30.	316	8	•	92	ā	X
2.5.6.10.1.1.3 Sacramento Deep Water Ship Channel Food Study	x	X	X	X	х		1	5	: L	ı	93	Ē	x	x	47
2.5.6.10.1.1.4 North delta Food Subsidies/ Colusa Basin Drain and Suisun Marsh Roaring River Distribution System Food Subsidy Studies	х	8	х	X	X	74	-	2	-	T.	æ.	Y21	х	1	¥.
2.5.6.10.1.2.1 Tidal Habitat Restoration of 8,000 acres	r ce	-	-	х	-		-			-		Œ	х		:=03
2.5.6.10.1.2.2 Predator Hot Spots	х	1	-	X	-	-	-	-	841	-	1211	(=)	1	_	320
2.5.6.10.1.3.2	-	- 2	-	X	-	-		20	3	-	126	X	-	2	4

Project Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
Delta Fish Species Conservation Hatchery															

2.5.5.1 Delta Conceptual Model and Recent Delta Science

There are a variety of stressors affecting juvenile salmonids outmigrating through the Delta, many of which likely interact with project operations (Figure 2.5.5-1). The many interacting factors make it hard to isolate or quantify the effect of any one stressor, especially on "large-scale" effects metrics such as through-Delta survival. The correlations among environmental variables add to the challenge.

NMFS considers several types of water project-related effects on salmonids in the south Delta as captured in the focal framework of the 2017 Salmonid Scoping Team (SST) report which links hydrodynamics to migration behavior and finally to survival Figure 2.5.5-2).

The SST report (Salmonid Scoping Team 2017a) summarizes recent science relevant to key, but not all, project-related effects (Table 2.5.5-3, Table 2.5.5-4, Table 2.5.5-4).

Some key elements of NMFS's conceptual model of salmonid survival in the Delta, in the context of water operations, include:

- Effects of exports outside the facilities likely diminish with distance (Cavallo et al. 2015).
- Near-field effects on fish at the export facilities are just one element of project-related
 mortality in the Delta; more negative OMR flows are a proxy measure for changed
 hydrodynamics within the Delta. Those hydrodynamic effects are likely to increase
 residence time in the Delta, even for fish not entrained into the fish salvage facilities,
 increasing their exposure to predation and other stressors within the central and south
 Delta.
- Near-field effects of the CVP and SWP export facilities such as entrainment and loss, and
 far-field effects, such as potential migratory disruptions at junctions or in channels, may
 be linked to salmonid survival via different mechanisms so studies at one location may
 not be applicable Delta-wide. For example, a study that does not show an effect of OMR
 on salmonid routing at Turner Cut should not be cited as support for no OMR effects on
 through-Delta migration.

In the analysis of PA effects, NMFS considers whether and how different PA components may affect the following elements of through-Delta migration and survival, which all have different mechanistic links to flows and exports. These three elements are discussed at a conceptual model

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level in the sections immediately below, and discussed, when relevant, in the analysis for each PA component:

- Routing at junctions on the mainstem Sacramento River and San Joaquin River (e.g., Delta Cross Channel and Head of Old River);
- Movement rates and survival in channel reaches of the mainstem San Joaquin River and the interior channels of the south Delta; and
- Entrainment into the SWP and CVP fish salvage facilities and loss at those facilities.

For an overview of recent science relevant to Delta management, NMFS incorporates by reference the comprehensive January 2017 report, "Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta" (Salmonid Scoping Team 2017a). Written by the SST convened by the Collaborative Adaptive Management Team (which included technical staff from multiple agencies and stakeholder groups), the report provides an overview of the findings and uncertainties related to salmonids and water operations in the South Delta.

Additional highlights from selected reports and articles are summarized in Appendix I.

2.5.5.1.1 Routing at junctions on the mainstem Sacramento River and San Joaquin River

Because the routing "decision" occurs at the time the fish reaches the junction, local flow conditions at the time of arrival (including tidal effects), rather than daily or longer-term average flows, affect the outcome. However, proportional routing of fish can be estimated based on longer-term hydrodynamic measures assuming a uniform arrival of fish at the junction throughout the averaging period. NMFS is aware that routing at a junction depends on instantaneous flow fields and velocities at the junction in three dimensional space, the spatial distribution of fish as they enter the region of the junction space, and the individual behavior of the fish to the environmental variables it encounters in this space. However, in the vast majority of instances, there is little or no data that can be provided with the available tools at hand in a way that we can evaluate and quantify the specific hydrodynamics at a given junction. In light of the absence of this information, we use the next best approach, which may be more simplistic, but provides a platform for analysis. On the mainstem San Joaquin River, especially in the tidal reaches downstream of the Head of Old River, flow changes due to the tides are greater than flow changes due to export rates. One way which high San Joaquin River inflow may improve through-Delta survival is that it moves the region of tidal influence farther downstream and may lead to flow conditions at junctions that reduce routing into the interior Delta. Our conceptual model assumes that individual fish will enter the junction space over a discrete period of time (daily) and that daily net flows (tidally averaged in tidal regions) will influence the pattern of flow dispersal at the junction over the diurnal tidal cycle in which the fish is present in the junction space. Stronger downstream flows (more positive daily net flows) will move the tidally influenced zone farther downstream, and the junction will have less water flowing into it, either by magnitude or duration. The extensive work by Perry et al. (2018) parallels this concept, although in much greater detail for the Sacramento River adjacent to the DCC gates. Higher flows in the Sacramento River mute the tidal effect and less flow and fish go into the DCC route when the gates are open. Hydrodynamic conditions downstream of the junction have more pronounced riverine characteristics when flows are high, and there is less tidal influence in the area of the junction. A more detailed discussion of routing is provided in later sections of the

opinion (specific to the DCC or Head of Old River junction) and in Appendix B of Volume 1 of the 2017 SST report (Salmonid Scoping Team 2017a).

2.5.5.1.2 Movement rates and survival in channel reaches of the mainstem San Joaquin River and the interior channels of the south Delta

Much work in both the north and south Delta focuses on routing at junctions and reach-specific travel-time or survival for release groups of fish that may transit the Delta in a several-week period. However, few studies for example, (Vogel 2002) have addressed in-channel movements of individuals at finer temporal and spatial scales that may be most appropriate to link to mechanistic models of behavior. Since fish likely spend a majority of their time in channels, not at junctions, behaviors in response to flows in Delta channels are also important for understanding migratory behavior. Concern about fish behavior and survival in channels is one important element underlying concerns about minimizing disruptions to South Delta hydrodynamics, which can be influenced by many factors, but primarily tides, CVP and SWP exports, and inflow from the San Joaquin River to the Delta (usually referred to as "Vernalis inflow"). Of those three factors, exports and Vernalis inflow are the two project-related components. Examples of how exports and inflow affect South Delta hydrodynamics are shown in Figure 2.5.5-3 in Section 2.5.5.12 below. Net daily flows are a proxy measure for velocity distributions (more negative net daily flow is associated with a velocity distribution that includes more frequent and/or more extreme negative velocities compared to the velocity distribution associated with a less negative net daily flow) that is a more practicable management knob than instantaneous flows or velocity distributions. The specifics of how net daily flow relates to the underlying velocity distribution depends on location in the Delta, local channel geometry, and the associated stage discharge relationship. For example, the same increase in net flow will be associated with a smaller change in the underlying velocity distribution on the larger-channel mainstem San Joaquin River compared to the smaller-channel Old River. In another example, a location in the western Delta (with high tidal influence) and a location farther upstream (with less tidal influence) could have the same net flow but very different magnitudes of positive and negative velocities. At a given location (for example, at the Old River and Middle River gage locations used to measure OMR), NMFS considers a change in net daily flow a useful proxy measure for qualitative, directional changes in the underlying velocity distribution. The ROC on LTO BA provides data on both net flows (Old and Middle River flow, OMR) and velocity distributions under the COS (current modeling representation of project operations at the time of consultation) and PA. Throughout this effects section, when NMFS refers to effects of net OMR flow, NMFS is using it as a proxy for the underlying hydrodynamic conditions that mechanistically link to salmonid behavior and survival, both in terms of vulnerability to nearfield project-related effects (entrainment to the export facilities) and far-field project-related effects (such as potential migratory disruptions at junctions or in channels). OMR flow is a net daily flow that is a composite measure from two gages in Old River and Middle River downstream of the export facilities near Bacon Island. As noted previously, effects of exports outside the facilities likely diminish with distance, so net daily flows in the south Delta are expected to be more negative (or less positive) between the export facilities and the OMR gage locations, and less negative (or more positive) downstream of the OMR gage locations. A change in OMR flow is expected to be associated with changes (in the same direction, but not necessarily magnitude) in net flows and underlying velocity distributions across this "export effect gradient." Because exports can affect the flow split at the Head of Old River at a given

Vernalis flow, export rates (particularly at low Vernalis flows) can affect flows in the mainstem San Joaquin River immediately downstream of the Head of Old River junction. For this reason, OMR changes due to export changes (especially at low, steady, Vernalis flows) can also be used as an indirect proxy for potential changes to mainstem San Joaquin River flows – not because of the observed flows in Old River and Middle River, but because the OMR metric is a proxy for export change if Vernalis flows are relatively steady. Similarly, if exports are steady, the OMR metric is a proxy for Vernalis flow change and associated changes in flow on the mainstem San Joaquin River. Based on the level of exports reported in the COS and PA scenarios in the BA, South Delta hydrodynamics will generally look like scenarios in the top row under the COS, and like scenarios in the middle row under the PA. Since the BA modeling reports monthly export levels, daily export levels under either regime would be expected to have a greater range.

This is an area that needs further study. The 2017 SST Report identifies a gap in linking hydrodynamics to in-channel fish behavior -- smaller scale, mechanism-oriented, studies may be necessary (as a complement to measures of through-Delta survival) to better understand how fish react to local conditions.

Appendix H "Bay-Delta Aquatics Effects Figures" of the ROC on LTO BA provides several types of results related to hydrodynamic conditions in the Delta. The "proportion overlap" figures shown for the North Delta and South Delta for 3-month periods summarize the overlap of velocity distributions under two paired scenarios. NMFS focused on comparisons between the PA and COS, especially for the period including April and May, when the PA is most different from the COS in the Delta (Figure 2.5.5-4). Because overlaps of more than approximately 50 percent show as green, the distinctions between PA and COS are a bit difficult to discern but one can see that, as expected, the hydrodynamic changes from the increased exports in the March-May period (due primarily to changes in April and May in the PA) are greatest in the southernmost Delta near the export facilities and in the Old and Middle River corridor. The change in velocity distributions is more clearly captured in the location specific velocity overlap plots (Figure 2.5.5-5), which show that (again for the March-May period) that the magnitude and frequency of positive, downstream flows, are decreased in the PA relative to the COS.

2.5.5.1.3 Entrainment into the SWP and CVP facilities and loss at those facilities

Once a fish is entrained into the CVP or SWP export facility, higher export rates may improve salvage efficiency. However, the bigger picture is that higher exports likely also increase overall entrainment, and modifies hydrodynamic conditions outside of the fish salvage facilities, as discussed above. The SWP has very poor salvage rates compared to the CVP.

2.5.5.1.4 Delta Survival

Several studies conducted on salmonid migration through the Sacramento-San Joaquin Delta provide an understanding of how Delta inflow affects juvenile salmonid survival (Newman 2003, Perry et al. 2010, Perry et al. 2013). These studies help to define the relationship of Sacramento River flow (at Freeport) and survival of juvenile salmon through the Delta, as well as the importance that fish migration routing has on migratory success. The acoustic tag studies (Perry et al. 2010, Perry et al. 2015, Perry et al. 2018) indicate that survival probability increases with increasing flows, and changes in survival are steepest when flows are below 30,000 cfs at Freeport. The flow-survival relationship is strongest at lower flows, and in the reaches that

transition from riverine to strong tidal influence. The relationship between flow and survival is in agreement with the assumptions and results of the velocity and entrainment analyses that indicated low, slack, and reverse velocities increase entrainment risk and increase travel time, which reduce survival probabilities. For example, entrainment into the interior Delta via Georgiana Slough or Delta Cross Channel (DCC) is increased when flows in the mainstem Sacramento River are low, reversing, or stagnant, and the proportion of fish remaining in the Sacramento River or entering Sutter or Steamboat slough increase under high inflows (Perry et al. 2018). While the mechanisms causing reduced survival probabilities are likely combinations of reduced velocities, route selection, and increased entrainment into the interior Delta, the flow-survival relationship can be used to collectively evaluate effects of flow changes on through-Delta survival.

NMFS uses three models that predict survival probabilities for smolts that enter the Delta through the Sacramento River Basin: DPM, WRLCM using Newman (2003), and Perry et al. (2019). NMFS also incorporated into the Opinion the Salvage Density model. These models analyze how entrainment loss in the south Delta fish salvage facilities changes under the scenarios, and we also use those analyses to help assess effects on overall south Delta effects.

Perry et al. (2019) and DPM are based on telemetry data which allowed for collection of environmental and hydrological data synchronous with the fate of individual fish as they migrate through the north and central Delta. The equation from Newman (2003) relating exports to survival used in the WRLCM is based on coded-wire tag studies over multiple years and relies heavily on statistical correlation between fish recapture and more broad or generalized environmental/hydrological data.

Delta Passage Model

The DPM integrates operational effects of the COS and PA that could influence survival of migrating juvenile Chinook salmon through the Delta. This includes differences in channel flows (flow-survival relationships), differences in routing based on flow proportions (e.g., entry into the interior Delta, where survival is lower), and differences in south Delta exports (export-survival relationships). The DPM provides estimates of through-Delta survival for both scenarios over the five water year types, as well as overall survival covering the full 81 years (1923 – 2003) of simulation through DSM2 and CalSimII. The DPM estimated through Delta survival for winter-run, CV spring-run, fall-run and late fall-run Chinook salmon.

The DPM used 75 iterations of the model for each scenario and reported the mean survival value as well as the 25th and 75th percentile values for each year within the 81 years used in the CalSimII and DSM2 modeling. The DPM output conveyed survival as a decimal fraction of survival (i.e., 1.00 is 100 percent survival, and 0.500 is 50 percent survival). For the purposes of this assessment, only the reported mean survival value was used for the comparisons between the PA and the COS scenarios. NMFS compared the two scenarios by taking the difference between reported mean survival values between the PA and COS scenarios for each year within the 81 year period used for the CalSimII and DSM2 modeling; that is, PA – COS= difference in mean survival for each year. The results were summarized for all water years combined for the 81 year period from 1923 - 2003, and by individual water year type, i.e., Wet, Above Normal, Below Normal, Dry, and Critical). The difference reported in the modeling was in absolute decimal fractions (that is 0.50 survival is equivalent to 50 percent survival). Summary statistics were run for each group of results (i.e., all years, and by water year types) and the median value reported

for the difference between the PA and COS scenarios. These median values were then reported here as percentages (i.e., a difference of 0.001 decimal fraction in survival is 0.1 percent difference in survival). Finally, relative changes between the COS and the PA were determined by calculating the differences between the median values of the PA and COS scenarios and presenting that value as a percentage of the COS value (i.e., (PA-COS/COS) *100; the percentage difference in relative terms to the COS value).

Winter-run Chinook Salmon

Overall, winter-run Chinook salmon had the best estimated through-Delta survival of the four different Chinook salmon runs modeled using the DPM. The median through Delta survival, as modeled by the DPM, was approximately 34 percent for all years simulated for both the COS and PA operations, with only slight differences between the two scenarios. The absolute through-Delta survival was highest in below normal water year types for both scenarios (~45 percent through Delta survival). Based on the differences in through-Delta survival between the two scenarios, the PA had slightly better through-Delta survival estimates for Wet, Above Normal, and Below Normal water year types, but was slightly lower than the COS during Dry and Critical water year types. Over all the years in the modeling simulation, the PA was slightly lower in overall median through-Delta survival by 0.070 percent. The absolute differences in modeled median through-Delta survival ranged from approximately +0.009 to -0.24 percent between the PA and COS for each water year type are as follows:

Wet
 Above Normal
 Below Normal
 Dry
 Critical
 40.01 percent (PA greater survival rate)
 -0.02 percent (PA lower survival rate)
 -0.24 percent (PA lower survival rate)
 -0.21 percent (PA lower survival rate)

Overall, both the absolute and relative differences in through-Delta survival are slight between the PA and COS. The relative difference in survival is less than 1 percent across all years in the simulation. This is to be expected as the most substantial changes in export levels in the south Delta occur in months when the majority of winter-run Chinook salmon have already migrated through the Delta. Increases in exports during April and May would only affect a small proportion of the emigrating population that is still within the Delta, as most winter-run Chinook salmon have exited the Delta by the end of March, and therefore would not be exposed to the increased export conditions.

CV Spring-run Chinook Salmon

As modeled by the DPM, CV spring-run Chinook salmon had a median through-Delta survival rate of approximately 30 percent over the 81 years modeled from the DSM2 and CalSimII simulations, ranging from approximately 20 percent to 52 percent for both scenarios. The median through-Delta survival rate was highest in Wet water year types (~43 percent) for both the COS and PA scenarios. Across all years and water year types, the PA had lower median through-Delta survival rates. Across all years in the 81-year simulation period, the median difference between the PA and COS through-Delta survival rate is -0.51 percent. The largest difference between the PA and COS occurred in above normal and below normal water year types. The absolute differences in modeled median through-Delta survival ranged from approximately -0.14 to -0.98 percent between the PA and COS for each water year type are as follows:

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•	Wet	-0.98 percent (PA lower survival rate)
•	Above Normal	-0.78 percent (PA lower survival rate)
•	Below Normal	-0.66 percent (PA lower survival rate)
•	Dry	-0.11 percent (PA lower survival rate)
•	Critical	-0.14 percent (PA lower survival rate)

The overall changes in through-Delta survival for CV spring-run Chinook salmon is also slight. However, the median PA through-Delta survival rate is lower than the COS in all but Critical water year types, and has a greater absolute and relative percentage change than was observed for winter-run Chinook salmon in the DPM modeling. The relative changes in median survival was 1.4 percent lower for the PA compared to the COS. The overlap of the CV spring-run emigration period with the increased exports in April and May are the likely cause for the reduced through-Delta survival rates modeled by the DPM.

CV Fall-run Chinook Salmon

The results of the DPM for CV fall-run Chinook salmon estimate that the median through-Delta survival is approximately 24 to 25 percent for both the PA and the COS, with the PA being slightly lower. The PA median through-Delta survival for all 81 years of DSM2 CalSimII simulations included in the DPM was 0.32 percent lower than the COS for the same period. The largest differences between the PA and COS through-Delta survival rates occurred in Wet water year types (1.1 percent lower under the PA). The absolute differences in modeled median through-Delta survival ranged from +0.76 to -1.1 percent between the PA and COS for each water year type are as follows:

•	Wet	-1.14 percent (PA greater survival rate)
•	Above Normal	-0.95 percent (PA lower survival rate)
•	Below Normal	-0.09 percent (PA lower survival rate)
•	Dry	0.76 percent (PA lower survival rate)
•	Critical	0.30 percent (PA lower survival rate)

The overall changes in absolute through Delta survival for CV fall-run Chinook salmon are also slight. The PA has better through-Delta survival in Dry and Critical water year types, but then has lower survival in all of the remaining water year types. The overall through-Delta survival rate over the 81-year DSM2 and CalSim II simulation period included in the DPM is also less for the PA compared to the COS, and is similar to the rate for winter-run Chinook salmon and CV spring-run Chinook salmon (~0.3 percent lower). Fall-run Chinook salmon emigrate at similar times as YOY CV spring-run Chinook salmon, and the effects of increased exports during the April and May period would negatively affect both runs.

CV Late Fall-run Chinook Salmon

The DPM results for late fall-run Chinook salmon estimate that the median through-Delta survival is approximately 21 to 25 percent for both the COS and PA, with the PA consistently lower across all years and by water year type. Over the 82-year DSM2 and CalSimII simulation period included in the DPM, the PA had a median through-Delta survival rate that was 0.23 percent lower than the COS. The largest differences between the PA and COS occurred in Wet water year types. The absolute differences in through-Delta survival ranged from -2.02 to -0.08 percent between the PA and the COS for each water year type are as follows:

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Wet -2.02 percent (PA lower survival rate)
 Above Normal -0.08 percent (PA lower survival rate)
 Below Normal -0.15 percent (PA lower survival rate)
 Dry -1.14 percent (PA lower survival rate)
 Critical -0.19 percent (PA lower survival rate)

The overall changes in through-Delta survival are slight. In all water year types and over the 81-year DSM2 and CalSimII simulation period included in the DPM, the PA has a lower through-Delta survival rate, particularly in Wet water year types where the difference is over 1 percent absolute (7.0 percent relative change). The lower overall survival is likely due to the earlier emigration period for late-fall run Chinook salmon, which spans a broader spectrum of flows in the Sacramento River and export actions in the South Delta during the fall and early winter.

CCV Steelhead

The DPM does not model CCV steelhead survival as it is based on the data derived from acoustic tag studies using Chinook salmon. Since the DPM is based on Chinook salmon, only a generalized association can be made with CCV steelhead smolts, which are typically larger and have somewhat different behaviors associated with their downstream migration as smolts (Chapman et al. 2013).

Given that the majority of results for Chinook salmon through-Delta survival have shown that survival under the PA conditions are less than under the COS conditions, it would be reasonable to conclude that CCV steelhead smolts emigrating through the Delta at the same time and under the same conditions assumed for the PA would also have reduced survival under the PA conditions compared to the COS, although the magnitude of the difference is uncertain due to differences between Chinook salmon and CCV steelhead.

sDPS Green Sturgeon

The DPM modeling does not apply to green sturgeon and is not used to assess impacts to survival under the PA for any life stage of sDPS green sturgeon.

Winter-run Chinook Salmon Life Cycle Model (WRLCM)

The WRLCM can estimate survival of emigrating winter-run Chinook salmon smolts to Chipps Island that have reared in different habitats within the Sacramento River system, including those that have reared in the Delta. Although not a strict one-to-one comparison, the results of the WRLCM that estimates the survival of smolts rearing in the Delta to Chipps Island under the PA and COS conditions can be compared to the through-Delta survival estimates of the DPM in a parallel fashion. Factors which reduce survival (flows, exports, routing into the interior Delta, etc.) are components of both models. The WRLCM estimates that winter-run Chinook salmon smolts that emigrate in January of Wet water year types will have slightly better median survival (3.2 percent) under the PA than the COS. Survival estimates remain higher for the PA compared to the COS in February and March, but are slightly less than January during the Wet water year types. By April and May, the survival under the PA is estimated to be less than the COS, up to 7 percent (absolute) in April, and 3 percent in May. The reductions in survival under the PA are likely due to the increases in south Delta exports during these months compared to the COS conditions, which are modeled using the equations from Newman (2003) relating exports to survival. This reduction in survival during the month of April for winter-run Chinook salmon

smolts originating in the Delta holds true for all water year types for the months of April and May, though most winter-run Chinook salmon juveniles have exited the Delta by mid-April. The estimates of survival to Chipps Island for Delta origin winter-run Chinook salmon smolts is consistently higher for the COS conditions compared to the PA conditions for the remaining water year types. April consistently has the greatest difference in survival between the PA and COS conditions, with up to 9.4 percent difference in below normal years. Overall the PA has lower survival rates for winter-run Chinook salmon smolts emigrating to Chipps Island for fish originating in the Delta, except for the period of January through March in Wet water year types. This parallels the general findings of the DPM for winter-run Chinook salmon migrating through the Delta, which found reduced survival for the PA for Below Normal, Dry, and Critical water year types, and only slightly higher survival for Wet and Above Normal water year types.

Perry Survival Model

The Perry Survival Model (STARs model) combines equations from statistical models that estimate the relationship of Sacramento River inflows (measured at Freeport) on reach-specific travel time, survival, and routing of acoustic-tagged juvenile late-fall Chinook salmon. Given these equations, daily cohorts of juvenile Chinook salmon migrating through the Delta under the CalSim simulations of the PA and the COS were simulated. Daily Delta Cross Channel gate operations from the DSM2 simulations of the PA and COS were also included. Statistical analysis of travel time and survival in eight discrete reaches of the Delta was used for assessing travel time and survival under the PA and COS scenarios. This analysis was based on acoustic telemetry data from several published studies where details of each study can be found (Perry et al. 2010, Perry et al. 2013, Michel et al. 2015). The data for the analysis consisted of 2,170 acoustic tagged late fall-run Chinook salmon released during a 5-year period (2007-2011) over a wide range of Sacramento River inflows (6,816 – 76,986 ft³/s at Freeport). There is the potential that flows outside of this range may not be adequately represented in the model. The model does not use any export-survival relationships, and thus reflects only the influence of Delta inflow, routing, DCC gate operations, and travel time on through Delta survival.

The simulation output for each day was summarized graphically to provide a number of useful statistics for each daily cohort:

- The proportion of fish using each unique migration route.
- The median daily travel time through the Delta.
- The median daily through-Delta survival.
- The probability of entering the interior Delta.
- Daily difference in survival, routing into the Delta interior, and median travel time between the PA and COS.

The difference in daily through-Delta survival between the PA and COS was summarized with graphics that display the distribution of survival differences among the 82 years of the simulation for a given date from October through July. This analysis is unique in that it summarizes daily through-Delta survival of the paired scenarios so it is more realistic of differences in survival that fish would experience under the scenarios on any given day (though it still captures limited variability in flow due to the underlying monthly CalSimII modeling). This is a more realistic representation of effects experienced by outmigrating smolts than the summary statistics used in some of the other methods used in this opinion. Results of the DPM and Winter-run Life Cycle

Model, for example, provide data summarized over the entire year for each of the 82 years and then summarize those differences collectively and by water year type. This grouping of results can dampen the level of effect that an individual fish may experience at a smaller time scale which may underestimate the actual impact to survival.

To understand how survival differences arise, it is useful to examine how the individual components of migration routing, survival, and travel time contribute to overall survival in a particular year. Figure 2.5.5-6, Figure 2.5.5-7, and Figure 2.5.5-8 illustrate detailed model output for 1979, a below normal year water year that exhibited flows ranging from 10,000 cfs to 30,000 cfs in the Sacramento River at Freeport. Delta inflow, specifically Freeport flow, is used as a predictor of survival, travel time, and route entrainment into the interior Delta. When Freeport flows are higher, through-Delta survival increases, and travel time decreases through the Delta. In addition, the probability of entering the Delta interior increases when the DCC gates are open, but also decreases when Freeport flows are higher. In Figure 2.5.5-6, there are differences in the flows at Freeport early in the water year (October through January) with modeled flows in the PA higher in October, but lower from November through December compared to the COS.

The modeling of the operations of the DCC gates results in differences between the two scenarios and reflect differences in upstream operations between the two scenarios. Because the model cannot capture Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI), it uses a flow-based relationship to estimate the number of days when fish are likely to be present. Specifically, the CalSimII model estimates the number of days that the flow at Wilkins Slough would be greater than 7,500 cfs using a relationship derived from historical monthly flows and closes DCC for that many days in a month within the Oct 1-Dec 14 period. While the model code is exactly the same for the COS and the PA, higher flows at Wilkins Slough result in a greater number of days of closure. Because the COS scenario includes the 2008 USFWS Opinion Fall X2 component in wet and above normal years, flows at Wilkins Slough are higher for the COS than for the PA in those year types, and there are more frequent exceedances of the 7,500 cfs threshold and associated modeled closures of the DCC gates. The modeled flows in October and November of wet and above normal years are generally lower under the PA and therefore do not trigger closure of the DCC as often (Sumer 2019). In real-time operations, gate closure would be governed by the KLCI and the SCI and thus may provide equal or better protection than exhibited in the modeling.

This difference in DCC gate operations between the COS and PA is particularly apparent in October and November where through-Delta survival is approximately 45 percent in November for the COS, compared to approximately 30 percent for the PA (middle panel), with a difference in through-Delta survival of about 12-15 percent (bottom panel). In spring (May through June) the modeled flows at Freeport are slightly higher for the PA than for the COS, which translate into slightly higher through-Delta survival (middle panel), and a slightly positive difference in through-Delta survival of about 1-2 percent (bottom panel; PA is greater than COS). The responses for routing into the interior Delta and travel time through the delta reflect the expected responses to changes in Delta inflow and DCC gate position. With the DCC gates open for the PA and closed for the COS, and lower Freeport flows for the PA compared to the COS, there is a higher probability of entering the Delta interior under the PA (Figure 2.5.5-7; middle and bottom panels). Conversely, in spring, the DCC gates are closed for both scenarios, but Freeport flow is higher for the PA, and thus there is a lower probability of entering the interior Delta for the PA compared to the COS. In Figure 2.5.5-8, higher Freeport flows for the COS coupled with a

closed DCC gate reduces the median travel time through the Delta compared to the PA by almost 2 days in the fall. Conversely in spring, when the PA has slightly higher Freeport flows and the DCC gates are closed for both the PA and COS conditions, the PA has slightly faster median travel times through the Delta of approximately 1 day. These general relationships between Delta inflow at Freeport, and the position of the DCC gates are observed throughout the modeled 82 years.

In Figure 2.5.5-9, the boxplots show the distribution of the probability that through-Delta survival for the PA scenario is less than survival for COS over the 82-year period of the modeling for each individual day between October and July. The box plots for each day summarize the data for the 82 years of simulation, with the median depicted as a point in each box, and the box hinges representing the 25th and 75th percentiles. The whisker bars represent the minimum and maximum values over the 82-year period. In fall (October through November), the median point of each boxplot shows that in 50 percent of the years, the probability that the difference between the PA and COS is less than zero is between 60 percent and ~100 percent. By late November – early December, the median probability (50 percent of years) that the difference between the PA and COS is less than zero has fallen to approximately 20 percent. From late December through mid-January, the median probability increases so that in 50 percent of the years, the probability that the through-Delta survival for the PA is less than the COS has risen to nearly 70 percent. For the period between February and late March, the median probability (i.e., in 50 percent of years) that the PA through-Delta survival is less than the COS is approximately 20 percent. An additional increase in the probability that the PA has a lower through-Delta survival occurs during the first half of April. From late April through June, the probability that in 50 percent of the years that the PA has a lower through-Delta survival than the COS is essentially zero. In summary, the COS condition has a high potential to have greater through-Delta survival during three periods of the year: fall (October and November), from mid-December through mid-January, and again in early April.

The probability that the difference in median travel times through the Delta between the PA and COS conditions is greater than zero is depicted in Figure 2.5.5-10. This means that travel time is longer for the PA compared to the COS. The box plots for each day summarize the data for the 82 years of simulation as described in the previous paragraph. Similar to the previous figure, the probability that the median travel time is greater for the PA compared to the COS is high for several periods during the year. From October through November, the probability that the difference in median travel times through the Delta between the PA and COS being greater than zero is greater than 60 percent for 50 percent of years modeled. There are two additional large peaks in the probability that the PA has longer median travel times during the year, one occurring in January, and the second occurring in April. In contrast, there is little or no probability that the differences between median travel times through the Delta between the PA and COS scenarios are greater than zero from February to April and from late April to mid-June.

Figure 2.5.5-11 depicts the distribution in the probability that the PA will have a greater potential to have fish routed into the Delta interior compared to the COS over the 82-year period of the modeling for each individual day between October and July. The box plots are constructed as previously described. There is a higher probability that from October through November, the PA will have a greater potential to route fish into the Delta interior, with 50 percent of the years having up to an 80 percent probability that the difference between the PA and COS will be greater than zero. From December through late May, there is low probability that the PA will

have a greater potential to route fish into the Delta interior compared to the COS. This is to be expected as the DCC gates are typically closed during this time for both scenarios. The DCC gates typically open up for the summer starting in June, and the increase in the difference between the PA and COS conditions may reflect operational differences upstream of the Delta under the PA rather than DCC gate conditions, as under both scenarios the gates are open.

Figure 2.5.5-12 depicts the daily median differences in through-Delta survival between the PA and COS. During the fall period (October through December), through-Delta survival is better under the COS compared to the PA. Differences in survival can range up to 15 percent better under the COS (whisker bars) but can be approximately 10 percent better in up to 25 percent of the years modeled (25 percent interquartile hinge point). The median difference is slightly less than zero in absolute terms for most of this period, and the 75th percentile is essentially zero from October through November. In December, there is a slight reversal in survival differences (75th percentile quartile is slightly positive, approximately 1 percent) but the daily median difference of through-Delta survival shows little difference between the PA and COS, essentially tracking the zero line. From mid-April through June there is a slight increase in the difference between the PA and COS, with the PA having slightly better (1-2 percent better 75th percentile interquartile) through-Delta survival.

Figure 2.5.5-13 and Figure 2.5.5-14 depict the daily differences in median travel time through the Delta and the percentage of fish routed into the Delta interior between the PA and COS conditions for each individual day based on the 82 years in the modeling. The figures show the effect of the changes in Delta inflow and operations of the DCC gate during the fall period (October through November). In response to lower flows in the PA and a greater potential for periods of open DCC gates, there is an increase in the median travel time through the Delta for the PA and a greater percentage of routing into the Delta interior. This shows up as a positive difference between the PA and COS. The median difference in travel time through the Delta is approximately 0.1 days, but the 75th percentile value can reach up to a difference of 1 day in November. In contrast, the PA has faster travel times in the spring (mid-April through June) and the differences are negative (shorter travel time for the PA compared to the COS). The median difference can be as much as half a day faster travel time through the Delta, with the lower 25th percentile values being nearly 1 day in late May and early June. It is not unexpected that the travel time through the Delta is longer in the fall under the PA, as the potential to be routed into the Delta interior is also increased during this period. This is a reflection of lower Delta inflows in November under the PA and a higher likelihood that the DCC gates will be open compared to the COS.

The box plots in Figure 2.5.5-15 depict the differences in through-Delta survival between the PA and COS by water year type. In each of the water year types, the PA has a greater potential to have lower through-Delta survival in the fall. The median values of the differences are little different than zero, however the 25th percentile values indicate that differences in survival may range up to 10 percent less for the PA than the COS. There is less difference in critical years compared to the other four water year types. For the remainder of the year (December through June) there is little difference in the through-Delta survival between the PA and the COS. In wet years there is a small increase (~1 percent) in survival under the PA scenario compared to the COS in December. There are also similar increases in below normal and dry water year types during this December period, but the magnitude is much smaller. As seen previously, there is

also a small increase in through-Delta survival under the PA conditions in the spring, centered on May and June, but it is very small in magnitude (< 1 percent).

The box plots in Figure 2.5.5-16 depict the differences in median travel time between the PA and COS conditions by water year type. In all water year types, there is an increase in the median travel time difference between the PA and COS in the fall period (October through November) indicating that the travel time in the PA is longer than the COS. The peak difference between the PA and COS during the fall occurs in early November. The 75th percentile values for the wet, above normal, below normal, and dry water year types are approximately 1 day longer for the PA than the COS during this period. The difference in critical water years is slightly less. In wet water years, the PA has slightly shorter travel times than the COS in December, which is also reflected by the increased through-Delta survival for the PA during this period. During the remainder of the year, but particularly in the spring period, there are periods in which the PA has reduced travel times compared to the COS. From December through May, these reductions in through-Delta travel times are typically slight. Larger reductions in the through-Delta travel times for the PA compared to the COS are seen in May and June.

The box plots in Figure 2.5.5-17 depict the daily median differences in the interior routing between the PA and COS conditions by water year type. In each water year type, there is a higher likelihood that a greater percentage of fish will be routed into the Delta interior during October through November under the PA scenario than under the COS. While the median value of the differences between the PA and COS is typically little different than zero, the 75th percentile of the box plot indicates that the PA can be 5 to 10 percent higher in routing fish into the Delta interior during this period. This is expected given the lower Delta inflows for the PA during this period and the greater likelihood that the DCC gates are open. The difference between the PA and COS routing is less in critical water year types compared to the other water year types. As expected, during the spring, when the PA tends to have slightly better inflows to the Delta, the percent of fish routed into the Delta interior is slightly lower for the PA compared to the COS.

Winter-run Chinook Salmon Exposure and Risk

The Perry Survival Model comprehensively looks at factors that affect survival, such as travel time, routing into the Delta interior, and operations of the DCC gates, to evaluate how changes in Delta inflow will affect smolt migratory success between the PA and COS scenarios. Since daily results are segregated by month and then further by water year type, we can thoroughly examine the exposure and risk associated with these changes for winter-run Chinook salmon smolts.

The main migratory period for winter-run Chinook salmon juveniles is October through April. Based on the modeling outputs, juvenile winter-run entering the Delta from the Sacramento River in October or November will have a greater risk of being routed into the Delta interior through open DCC gates associated with lower Delta inflows under the PA compared to the COS (Figure 2.5.5-14 and Figure 2.5.5-17). These routes have the potential to have longer travel times through the Delta for the PA compared to the COS (Figure 2.5.5-13 and Figure 2.5.5-16), which in turn is expected to create conditions that have lower through-Delta survival for migrating winter-run Chinook salmon (Figure 2.5.5-12 and Figure 2.5.5-15). Based on the modeling, survival could be reduced up to approximately 10 percent (lower 25th percentile) during the October through November period in wet, above normal, below normal, and dry years. In critical years, the reduction is less. This would affect approximately 5 percent of the brood year

population based on historical fish monitoring. In wet years, higher Delta inflows in December under the PA, coupled with closed DCC gates would provide a small improvement in through-Delta survival for winter-run emigrants entering the Delta. Increased flows reduce travel times and the potential for routing into the Delta interior at other junctions (i.e., Georgiana Slough). This would benefit approximately 10 to 25 percent of the winter-run brood year population which enter the Delta during December. For the rest of the juvenile winter-run Chinook salmon migration period (January through April) the modeling shows little difference in through-Delta survival and routing into the Delta interior, and very minor improvements in through-Delta travel times. Overall, the PA is expected to negatively affect approximately 5 percent of the annual brood year population that may potentially emigrate into the Delta in October or November. Positive survival effects are likely to occur only in wet years during December, to approximately 10 to 25 percent of the annual brood year population emigrating into the Delta.

CV spring-run Chinook salmon Exposure and Risk

The main migratory period for CV spring-run Chinook salmon juveniles is December through May. Older yearling CV spring-run Chinook salmon are expected to start emigrating into the Delta starting in October and continuing through January and into February. Like juvenile winter-run Chinook salmon, yearling CV spring-run Chinook salmon will be exposed to the higher risks of being routed into the Delta interior through open DCC gates. The open gates are associated with lower Delta inflows under the PA as compared to the COS. Fish following these routes will potentially have longer travel times through the Delta under the PA compared to the COS. Longer routes are associated with conditions that may lead to a reduction in through-Delta survival under the PA. This is expected to occur in all water year types (Figure 2.5.5-15), however the reduction will be a lower in critical water year types. Like juvenile winter-run Chinook salmon, yearling CV spring-run Chinook salmon that emigrate into the Delta in December of wet water year types will likely see better conditions and have higher through-Delta survival. This is in part due to the higher forecasted Delta inflows in December of wet years, coupled with closed DCC gates reducing routing into the Delta interior. Increased flows reduce travel times and the potential for routing into the Delta interior at other junctions (i.e., Georgiana Slough).

Very few juvenile CV spring run Chinook salmon would be present emigrating to the Delta prior to January. From January through the beginning of April there is very little difference between the through-Delta survival rate for the PA and COS. Improvements in the PA through-Delta survival rate begin to occur in mid-April when the difference between the PA and COS becomes positive. This indicates that the PA has better survival than the COS, although the magnitude of improvement is fairly small (approximately 1-2 percent at the 75th percentile level). Part of this improvement is due to higher levels of Delta inflow proposed for the PA. Based on historical monitoring, the last 50 percent of the annual brood year of CV spring-run Chinook salmon would be moving into the Delta during April and May. These fish would be exposed to the better through-Delta survival rates found in the mid-April through June period under the PA and would be expected to benefit from the improved conditions.

CCV Steelhead Exposure and Risk

The Perry Survival Model does not model CCV steelhead survival and movements as it is based on data derived from studies using acoustic tagged Chinook salmon in the Delta. Given that

steelhead and Chinook salmon have generally similar, but not identical migratory behaviors, only a generalized association can be made.

CCV steelhead smolts are present within the Delta in most months of the year but the main migratory season for smolts to move through the Delta is from November through June. It is reasonable to assume that CCV steelhead smolts emigrating through the Delta at the same time and under the same conditions assumed for the Perry Survival Model for Chinook salmon would experience the same Delta inflows, DCC gate operations, and hydraulic conditions at river junctions. The magnitude of response by CCV steelhead smolts may be different, but the general trends should be similar. For CCV steelhead smolts emigrating in the fall period during October and November, there is an increased likelihood that more fish will be entrained into the Delta interior through open DCC gates under the PA as compared to the COS. Fish that do so will have longer travel times through the Delta interior and more than likely have reduced through-Delta survival. Only a small proportion of the emigrating population of CCV steelhead smolts is expected to be present in the Delta during October and November. From December through April, there would be little difference between the PA and COS regarding routing and travel times, and therefore through-Delta survival should not vary much between the two scenarios. This is the period in which most CCV steelhead from the Sacramento River Basin emigrate through the Delta. From mid-April through June, the slight increase in flows coming into the Delta under the PA scenario should help reduce both travel time through the Delta and routing into the Delta interior at river junctions compared to the COS. These changes should increase through-Delta survival, although the fraction of the CCV steelhead affected during this period would be quite low as most steelhead from the Sacramento Basin have already emigrated.

sDPS of North American Green Sturgeon

The Perry Survival Model does not apply to sDPS green sturgeon and is not used to assess impacts to survival under the PA for any life stages of sDPS green sturgeon.

Summary

Based on the results of the Perry Survival Model, winter-run Chinook salmon juveniles and yearling spring-run Chinook salmon are the two groups of salmonids that will be affected most by the PA. Those fish that migrate through the Delta during October and November will see the largest differences in through-Delta survival, routing into the Delta interior, and travel times. Based on the results of the modeling for the October and November period, the PA will decrease through-Delta survival compared to the COS, increase the number of fish routed into the Delta interior compared to the COS, and increase the through Delta travel time of fish compared to the COS. It should be noted that these differences are driven in part by the operations of the DCC gates, which respond to the differences in river flow between the two scenarios as described above. Operations of the gates in real time, based on observations of fish in monitoring programs, may differ from the operations of the gates in the modeling, and thus provide equal or better protection than exhibited in the modeling. Finally, since the Perry Survival Model does not use any specific relationships between exports and survival, the model is relatively insensitive to the effects of changing exports. Likewise, the Perry Survival Model does not specifically use any data from studies conducted in the San Joaquin River side of the Delta, and therefore should not be used to interpret survival, routing, or travel times for salmonids entering the Delta from the San Joaquin River side of the Delta.

2.5.5.2 Presence of the Species within the Bay-Delta Division

The approach used for this analysis was to identify which ESA-listed species would likely to be present in the Bay-Delta region during the PA and exposed to the PA-related stressors. NMFS conducted a review of nearby CDFW and USFWS monitoring locations, run timing, and fish salvage data to determine the likelihood of ESA-listed fish presence (Table 2.5.5-5, Table 2.5.5-6, Table 2.5.5-7 and, Table 2.5.5-8. Adult salmonids typically migrate through the Delta within a few days. Juvenile Chinook salmon spend from 3 days to 3 months rearing and migrating through the Delta to the mouth of San Francisco Bay (Brandes and McLain 2001, MacFarlane and Norton 2002). Steelhead smolts have varied behaviors in their use of the Delta. Juvenile hatchery steelhead used in studies in the San Joaquin and southern Delta had longer transit times to Chipps Island than juvenile Chinook salmon released in the same location on the lower San Joaquin River. In contrast, Chapman et al. (2015), found that steelhead smolts rapidly moved through the San Francisco estuary system and entered the Pacific Ocean at the Golden Gate within days of entering the upper estuary (Suisun Bay). Some individual sDPS green sturgeon may move through the Delta region quickly from either upstream locations or from the estuary during their migratory behaviors, while others may spend a protracted amount of time within the Delta ranging from days to years while holding or rearing.

The Bay-Delta waterways function primarily as migratory corridors for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon, but they also provide some use as holding and rearing habitat for each of these species as well. Juvenile salmonids may use the area for rearing for several months during the winter and spring before migrating to the marine environment. Green sturgeon use the area for rearing and migration yearround. Generally, as flows increase in the fall and through the winter, adult salmon, CCV steelhead, and sDPS green sturgeon migrate upstream through the Sacramento and San Joaquin rivers and juveniles migrate downstream in the winter and spring. Adult winter-run Chinook salmon typically migrate through the estuary/Delta from November to June with the peak occurring in March (Table 2.5.5-5). Adult CV spring-run Chinook salmon migrate through the Delta from January to June (Table 2.5.5-6). Adult CCV steelhead migration into the Sacramento River watershed typically begins in August, with a peak in September and October, and extends through the winter to as late as May (Table 2.5.5-7). Adult sDPS green sturgeon start to migrate upstream to spawning reaches in February and their migrations can extend into July (Table 2.5.5-8), but may also be found holding in waters of the Sacramento River basin and Delta yearround.

2.5.5.2.1 Sacramento River Winter-run Chinook Salmon

Adult winter-run Chinook salmon are expected to be in the Bay-Delta region from November through June with a peak presence from February to April (Table 2.5.5-5) as they migrate upstream to spawn in the upper Sacramento River. Since the Delta is a transition zone between tidal and riverine sections of the Sacramento River, adult salmon sometimes wander through the Delta searching for specific olfactory cues that lead them to their natal spawning area. Winter-run Chinook salmon adults have been known to stray into the Sacramento Ship Channel (SSC) and around the Delta islands and sloughs as they make their way through the maze of channels leading to the main stem Sacramento River upstream of the Delta, including the Yolo Bypass when inundated.

For juvenile winter-run Chinook salmon, a review of fish monitoring data from 2000–2016 from the Chipps Island trawl and the Sacramento River trawl (Sherwood Harbor) showed very low numbers present from July through October (Speegle et al. 2013, Barnard et al. 2015, Miller et al. 2017, University of Washington Columbia Basin Research 2019) [USFWS DFJMP data 2000-2016 (U.S. Fish and Wildlife Service 2019)] (Figure 2.5.5-18 and Figure 2.5.5-19). Juvenile winter-run Chinook salmon occur in the Delta primarily from November through early May with a peak occurrence in March, using length-at-date criteria from trawl data in the Sacramento River near Sherwood Harbor (Speegle et al. 2013, Barnard et al. 2015, Miller et al. 2017) (Table 2.5.5-5).

There are no reported populations of winter-run Chinook salmon that spawn in the San Joaquin River basin. Presence of adults is unlikely in the channels of the Delta south of the main stem of the San Joaquin River. Adults may be stray into the channels of the Central Delta north of the main stem San Joaquin River as they try to regain access to the main stem Sacramento River through one of the major distributaries (i.e., Georgiana Slough and portions of the lower Mokelumne River system).

Based on acoustic telemetry studies using late fall-run hatchery Chinook salmon (Perry et al. 2010, Perry et al. 2012, Perry et al. 2013, Romine et al. 2013), substantial fractions of the emigrating juvenile winter-run Chinook salmon population are expected to take alternate routes through the Delta, in addition to the mainstem Sacramento River route. In the north Delta. emigrating salmon are expected to utilize Sutter and Steamboat sloughs as well as the mainstem Sacramento River to reach the western Delta. In addition, alternate routes through the Delta interior are possible through Georgiana Slough and, when the radial gates are open, the Mokelumne River system via the DCC. These interior Delta waterways will route fish to the San Joaquin River mainstem via the terminus of the Mokelumne River. During the period that juvenile winter-run Chinook salmon are moving through alternate routes, they may utilize the Delta for rearing. A study by del Rosario et al. (2013) found that winter-run Chinook salmon are present in the Delta for an extended period of time, with an apparent residence time ranging from 41 to 117 days, with longer apparent residence times for juveniles arriving earlier at Knights Landing, Individual fish present in the mainstern San Joaquin River are subject to tidal forcing and may move into the channels of Old and Middle rivers, as well as other channel junctions in this reach, rather than moving towards the western Delta. Juvenile winter-run Chinook salmon from the Sacramento River basin have been observed in salvage at the Tracy Fish Collection Facility (TFCF) and Skinner Delta Fish Protection Facility (SDFPF) in the south Delta, indicating that juvenile winter-run Chinook salmon have the potential to be present in the waterways leading to these facilities. Due to extensive tidal movement and the creation of reverse flows in the two main channels (Old and Middle rivers) leading to the export facilities due to the diversion of water at these facilities, juvenile winter-run may disperse into many of the waterways adjacent to the export facilities, including those waterways that contain the three south Delta agricultural barriers.

There are no spawning areas in the Bay-Delta region that could be used by adult winter-run Chinook salmon, therefore the potential that eggs would be present in the Bay-Delta region is nonexistent. Likewise, the potential for alevins/yolk sac fry to be present in the Bay-Delta region is also unlikely due to the distance of the spawning reaches in the upper Sacramento River locations from the Delta. Although it is improbable, heavy precipitation events in the upper river watersheds adjacent to the spawning reaches of the Sacramento River could create high river

flow conditions that stimulate fry and parr to migrate downstream to the Delta after emergence in the late summer and early fall, although precipitation events of this magnitude are more likely to occur later in the rainy season. Studies by Miller et al. (2010) and Sturrock et al. (2015) have shown that for Central Valley fall-run Chinook salmon, sizeable fractions of the adult escapement is made up of fish that left freshwater and entered the marine environment as fry or parr life stages, along with the typical smolt life stage that is expected. Miller et al. (2010) found that among the parr and fry life stages leaving the freshwater environment, a large fraction (25 percent of parr and 55 percent of fry migrants) spent time rearing in the brackish waters of the Bay-Delta region. A similar diversity of life history strategies may exist for winter-run Chinook salmon.

2.5.5.2.2 CV Spring-run Chinook Salmon

Adult CV spring-run Chinook salmon are expected to migrate upstream through the Bay-Delta region from January to June with a peak presence from February to April (Table 2.5.5-6). Like adult winter-run Chinook salmon, adult CV spring-run Chinook salmon could stray into the SSC or the network of sloughs and waterways surrounding the northern and central Delta islands during their upstream migration.

Juvenile CV spring-run (young of the year [YOY]) are present in the Bay-Delta region as they migrate to the ocean in the spring. Yearling spring-run Chinook salmon are expected to enter the Delta in late fall and early winter (late October through January). Juvenile spring-run Chinook salmon are expected to be present in the northern Delta region from December through May with a peak presence in March and April (Speegle et al. 2013, Barnard et al. 2015, Miller et al. 2017, University of Washington Columbia Basin Research 2019) [USFWS DFJMP data 2000-2016 (U.S. Fish and Wildlife Service 2019)] (Table 2.5.5-6, Figure 2.5.5-20, and Figure 2.5.5-21). Currently there are no documented non-experimental populations of CV spring-run Chinook salmon in the San Joaquin River basin that would likely occur in the Bay-Delta region. However, there is anecdotal evidence of Chinook salmon occurring in the Stanislaus and Tuolumne rivers that may represent residual populations of spring-run Chinook salmon or individuals that have strayed from other river basins and use the Stanislaus and Tuolumne rivers for spawning based on their run timing and the presence of fry and juveniles that show traits characteristic of springrun populations such as hatching dates and seasonal sizes (Franks 2013, National Marine Fisheries Service 2016a). Furthermore, the San Joaquin River Restoration Program (SJRRP) goal of re-establishing an experimental population of CV spring-run Chinook salmon in the San Joaquin River basin will create the potential that CV spring-run Chinook salmon will be present in the southern Delta and San Joaquin River regions of the Bay-Delta area over the lifetime of the PA. Note that in the CV spring-run Chinook Integration and Synthesis Section (Section 2.8.3), NMFS discusses the San Joaquin experimental population and associated 4(d) rule with respect to findings under this Biological Opinion.

There are no spawning areas in the Bay-Delta region that could be used by adult spring-run Chinook salmon, therefore the potential that eggs would be present in this area is nonexistent. Likewise, the potential for alevins and yolk-sac fry to be present in the Bay-Delta region is also unlikely, since only extreme precipitation events in the fall and early winter resulting in high river flows in the Sacramento or San Joaquin river basins could flush alevins out of their natal tributaries into the Delta. Fry and parr are more likely to be present in the Delta region in response to high river flows due to the timing of winter storms and the progressive maturation of

the fish. This period would be from approximately November through March. By April, juvenile spring-run Chinook salmon are reaching the size that smoltification occurs, and the majority of smolts would be moving downriver to enter the Delta on their emigration to the ocean. Spring-run Chinook salmon smolt outmigration is essentially over by mid-May with only a few late fish emigrating in early June. There is the potential that some juvenile CV spring-run Chinook salmon will remain in the tributaries through the summer and outmigrate the following fall and winter as yearlings (Table 2.5.5-6). Adult CV spring-run Chinook salmon are expected to be migrating upstream through the Bay-Delta from January to June with a peak presence from February to April (Table 2.5.5-6). In the San Joaquin River basin, adult migration is also likely to be strongly influenced by the flow levels in the San Joaquin River basin that provides access to the upstream holding and spawning areas. The broodstock for the spring-run Chinook salmon experimental population came from the Sacramento River basin (Feather River Fish Hatchery spring-run Chinook salmon) and are expected to exhibit similar migration timing behavior for both adult and juvenile life stages in the San Joaquin River basin.

2.5.5.2.3 CCV Steelhead

The majority of CCV steelhead originate in the Sacramento River basin and its multiple tributaries and are comprised of the Northern Sierra Nevada, Northwestern California, and Basalt and Porous Lava diversity groups. However, small, but persistent populations of CCV steelhead are present in the Calaveras River and San Joaquin River basin and are part of the Southern Sierra Nevada Diversity Group. Both adults and smolts are detected by monitoring efforts in these basins, indicating spawning is occurring in the basins' tributaries.

Natural CCV steelhead juveniles (smolts) can start to appear in the northern Bay-Delta region as early as October, based on the data from the Sacramento River and Chipps Island trawls (Speegle et al. 2013, Barnard et al. 2015, Miller et al. 2017, University of Washington Columbia Basin Research 2019); Figure 2.5.5-22 and Figure 2.5.5-23) and CVP/SWP fish salvage facilities (California Department of Fish and Wildlife 2018a). In the Sacramento River, juvenile CCV steelhead generally migrate to the ocean from early winter to early summer at 1 to 3 years of age and 100 to 250 mm FL, with peak migration through the Delta occurring in March and April (Reynolds et al. 1993). In the San Joaquin River basin, CCV steelhead smolts are expected to appear in the southern Bay-Delta regional waterways as early as January, based on observations in tributary monitoring studies on the Stanislaus River, but in very low numbers. The peak emigration in the lower San Joaquin River, as determined by the Mossdale trawls near the Head of Old River, occurs from April to May, but with presence of fish typically extending from late February to late June.

Juvenile CCV steelhead presence in CVP/SWP fish salvage facilities increases from November through January (12.4 percent of average annual salvage) and peaks in February (40.4 percent) and March (26.9 percent) before rapidly declining in April (13.3 percent) and May (4.4 percent) (National Marine Fisheries Service 2016b). By June, emigration essentially ends (Table 2.5.5-7), with only a small number of fish being salvaged through the summer at the CVP/SWP fish salvage facilities. Juvenile steelhead detected at the salvage facilities may arise from either the Sacramento River watershed or from the San Joaquin River watershed. Based on the timing of steelhead juveniles and smolts observed in monitoring programs, Sacramento River basin fish tend to enter the Delta earlier in the winter and spring than their counterparts in the San Joaquin River basin.

Adult steelhead begin to migrate through the northern portion of the Bay-Delta region (lower Sacramento River) starting in July and continue through late fall, with a secondary peak occurring in late spring (presumably adults returning downstream as post spawn fish, or "kelts"). The majority of adult steelhead migrate into the Sacramento River basin in late summer and fall on their upstream spawning run. The percentile of adult migration passage during this period is 2 percent for July, 12 percent for August, 44.5 percent for September, and 25 percent for October (Hallock et al. 1957, Hallock et al. 1961).

Adult steelhead in the San Joaquin River basin are expected to start moving upstream through the southern portion of the Bay-Delta region into the lower San Joaquin River as early as September, with the peak migration period occurring later in the fall during the November through January period, based on Stanislaus River fish weir counts. Adult CCV steelhead will continue to migrate upriver through March, with kelts moving downstream potentially through the spring and early summer, although most are expected to move back downstream earlier than later (Table 2.5.5-7).

2.5.5.2.4 Southern DPS of North American Green Sturgeon

Adult green sturgeon begin to enter the Bay-Delta in late February and early March during the initiation of their upstream spawning run (Moyle et al. 1995, Heublein et al. 2009). The peak of adult entrance into the Delta appears to occur in late February through early April, with fish arriving upstream of the Glen-Colusa Irrigation District's water diversion on the upper Sacramento River in April and May to access known spawning areas (Moyle 2002). Adults continue to enter the Delta until early summer (June-July) as they move upriver to spawn in the upper Sacramento River basin. It is also possible that some adult green sturgeon will be moving back downstream as early as April and May through the Bay-Delta region, either as early postspawners or as unsuccessful spawners. The majority of post-spawn adult green sturgeon will move down river to the Delta either in the summer or during the fall. Fish that over-summer in the upper Sacramento River will move downstream when the river water cools and rain events increase the river's flow and either hold in the Delta or migrate directly to the ocean. Data on green sturgeon distribution are extremely limited and out-migration appears to be variable occurring at different times of year. Eleven years of recreational fishing catch data for adult green sturgeon (California Department of Fish and Game 2008, 2009, 2010a, 2011, 2012, California Department of Fish and Wildlife 2013a, 2014a, 2015a, 2016a, 2017a, DuBois and Danos 2018) show that they are present in the Delta during all months of the year (Figure 2.5.5-24). Although the majority of green sturgeon are expected to be found along the Sacramento River corridor and within the western Delta, observations of green sturgeon occur in the San Joaquin River and upstream of the southern Delta region based on the information provided in the CDFW sturgeon fishing report cards. Presence of fish occurs during all seasons of the year, but primarily from fall through spring. Few fish are caught during the summer period.

Juvenile green sturgeon migrate to the sea when they are 1 to 4 years old (Moyle et al. 1995). According to Radtke (1966), juveniles were collected year round in the Delta during a 1-year study in 1963-1964. The DJFMP rarely collected juvenile green sturgeon at the seine and trawl monitoring sites. From 1981 to 2012, 7,200 juvenile green sturgeon were reported at the CVP/SWP fish salvage facilities (Figure 2.5.5-25), which indicates a higher presence of juvenile

green sturgeon during the spring and summer months in the south Delta where the export facilities are located.

Based on the above information, adult and juvenile sDPS green sturgeon were determined to be present in the Delta year-round (Table 2.5.5-8).

2.5.5.3 Delta Cross Channel Operations

2.5.5.3.1 Physical Description of the Delta Cross Channel Gate Infrastructure

The Delta Cross Channel (DCC) gates are located in Walnut Grove, California and are a part of Reclamation's Central Valley Project, Delta Division. The DCC is operated by the San Luis and Delta Mendota Water Authority. The DCC is a controlled diversion channel on the left (eastern) bank of the Sacramento River approximately 30 miles downstream of the city of Sacramento. The DCC was constructed by Reclamation in 1951 to redirect high quality Sacramento River water southwards through Snodgrass Slough into the channels of the Mokelumne River system for a distance of 15 miles until it meets the San Joaquin River, and then another 35 miles through Old and Middle rivers to the CVP and SWP export facilities near Tracy.

The manmade channel of the DCC is 6,000 feet long and has a bottom width of approximately 210 feet, with side slopes of 3:1 giving a total width of the 350 feet. The water depth of the channel is 26 feet deep with a nominal capacity of 3,500 cfs under normal conditions, but can divert up to 6,000 cfs if needed (Low and White 2004, 2006). Flow into the channel is controlled by two radial gates, each 60 feet wide by 30 feet tall, weighing a total of 243 tons. The gates extend 245 feet across the channel, creating a slight constriction of the channel.

The two gates are normally operated together. During high flows on the Sacramento River (greater than 20,000 to 25,000 cfs), the DCC gates are closed to prevent downstream flooding in the Snodgrass Slough and Mokelumne River systems. In addition, flows of this magnitude create scouring conditions at the DCC gate location and downstream of the facility, creating the potential for undercutting of the gate structure.

2.5.5.3.2 Deconstruct the Action - Proposed Operations of DCC Gates

Currently, Reclamation operates the DCC in the open position to (1) improve the transfer of water from the Sacramento River to the export facilities at the Banks and Jones Pumping Plants, (2) improve water quality in the southern Delta, and (3) reduce saltwater intrusion rates in the lower San Joaquin River in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta per the criteria in D-1641 and the NMFS 2009 BiOp (National Marine Fisheries Service 2009b) and to facilitate meeting the D-1641 Rio Vista flow objectives for fish passage.

The conditions for closing the DCC gates to protect fishery resources were first instituted in the State Water Resource Control Board's (SWRCB) D-1485 decision in 1978. In 1995, the Water Quality Control Plan (WQCP) for the Bay Delta (95-1) instituted additional operations of the DCC for fisheries protection (State Water Resources Control Board 1995). These criteria were reaffirmed in the SWRCB's D-1641 (State Water Resources Control Board 1999). Under the D-1641 criteria, the DCC gates may be closed for up to 45 days between November 1 and January 31 for fishery protection purposes. From February 1 through May 20, the gates are to remain closed for the protection of migrating fish in the Sacramento River. From May 21 through June

15, the gates may be closed for up to 14 days for fishery protection purposes. Reclamation determines the timing and duration of the closures after discussion with USFWS, CDFW, and NMFS. These discussions occurred through the water operations management team (WOMT) as part of the weekly review of CVP/SWP operations. WOMT used input from the Salmon Decision Process to make its gate closure recommendations to Reclamation.

Reclamation's current proposal (as discussed in the consultation meeting on May 21, 2019) under the PA is to operate the DCC gates to reduce juvenile salmonid entrainment risk beyond actions described in D-1641, consistent with Delta water quality requirements in D-1641 (U.S. Bureau of Reclamation 2019). From October 1 to November 30, if the KLCI or SCI are greater than three fish per day, Reclamation proposes to operate in accordance with Table 2.5.5-9 and Table 2.5.5-10 to determine whether to close the DCC gates and for how long. The KLCI and the SCI are computed from the daily catch per unit information from the Knights Landing rotary screw trap (RST) monitoring program, the Sacramento regional beach seines, and the Sacramento River trawl monitoring efforts and adjusted for a standardized 24 hours of effort (one day of monitoring effort). From December 1 to January 31, the DCC gates will be closed. If drought conditions are observed (i.e. fall inflow conditions are less than 90 percent of historic flows) Reclamation and DWR will consider opening the DCC gates for up to 5 days for up to two events within this period to avoid D-1641 water quality exceedances. Reclamation and DWR will coordinate with USFWS, NMFS and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements. Reclamation and DWR will conduct a risk assessment that will consider the Knights Landing RST, Delta juvenile fish monitoring program (Sacramento trawl, beach seines), Rio Vista flow standards, acoustic telemetered fish monitoring information as well as DSM2 modeling informed with recent hydrology, salinity, and tidal data. Reclamation will evaluate this information to determine if fish responses may be altered by DCC operations. If the risk assessment determines that survival, route entrainment, or behavior change to create a new adverse effect not considered under this proposed action, Reclamation will not open the DCC. During a DCC gates opening between December 1 and January 31, the CVP and SWP will divert at Health and Safety pumping levels.

The primary avenues for juvenile salmonids emigrating downstream in the Sacramento River to enter the interior Delta, and hence becoming vulnerable to entrainment by the export facilities, is by diversion into the DCC and Georgiana Slough. Therefore, the operation of the DCC gates may significantly affect the survival of juvenile salmonids emigrating from the Sacramento River basin towards the ocean. Survival in the Delta interior is substantially lower than the mainstem Sacramento River (Perry et al. 2010, Perry et al. 2012, Romine et al. 2013) (Need to add citation when in library).

NMFS made the following assumptions regarding the proposed operations for the analysis of effects, informed by the conversations during the consultation meeting on May 21, 2019, and analyzed effects accordingly:

- Frequency of DCC gate operations (opening gates) for water quality concerns during the fall and early winter remain similar to past water years;
- The Fish Monitoring Working Group, which is a new creation of the PA, will function in
 a similar manner to the currently existing DOSS working group and will meet at least
 once a week to provide near real-time analysis of fish monitoring data from the Central
 Valley to Reclamation; however, it is unclear what role the new group will have in

- providing recommendations for gate operations to Reclamation or to NMFS as has been done by the DOSS working group since 2010;
- Monitoring of older juvenile Chinook salmon (by length-at-date) catch will be the basis
 of the KLCI and SCI threshold triggers for closing the DCC gates;
- The DCC gates may be opened for up to 5 days for up to two water quality concern events from December 1 to January 31 when drought conditions are observed and gate opening will help to address water quality concerns; this operation is assumed to occur in less than 1 in 10 years.
- The proposed DCC gate operations follow the criteria for gate operations set forth in D-1641, and do not have more frequent gate openings than allowed during the February 1 through May 20 period.

2.5.5.3.3 Assess Species Exposure to Proposed DCC Operations

For the purposes of this analysis, "exposure" is defined as the temporal and spatial co-occurrence of the life stages of listed species (winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon) and the stressors associated with the PA. A few steps are involved in assessing listed species exposure. First, the life stages and associated timings of listed species are identified. The second step is to identify the spatial distribution of each life stage. The last step is to overlay the temporal and spatial distributions of PA-related stressors on top of the temporal and spatial distributions of the listed species with the location of the DCC gates and the effects of the stressors associated with its operations. A summary of the effects of the proposed DCC operations is provided in Table 2.5.5-61 in Section 2.5.5.13 Summary Tables of Stressors for each Project Component. NMFS does discuss, for comparative purposes, how DCC operations under the PA might differ from operations in the COS scenario.

There are four general periods for operations of the DCC gates under Reclamation's proposed procedures which differ slightly from those contained in the D-1641 operational criteria. From October 1 through November 30, the gates are operated per the actions described in Table 2.5.5-9. This period is different than the operations described in the D-1641 criteria. In general, Reclamation proposes for the DCC gates to remain open unless a trigger threshold is met by the observed catch indices at the Knights Landing RST monitoring location or from either of the monitoring efforts that comprise the SCI (Sacramento regional beach seines or the Sacramento trawl located near Sherwood Harbor on the Sacramento River). From December 1 through January 31, the DCC gates are proposed to be closed, unless drought conditions are observed and Reclamation determines that it can avoid D-1641 water quality exceedances by opening the DCC gates for up to 5 days for up to two events within this period. As noted earlier, this operation is assumed to occur in less than 1 in 10 years.

Under the COS, which includes actions required by the NMFS 2009 BiOp, the DCC gates are to be closed from December 1 through December 14 if the water quality criteria identified in D-1641 are met, with an exception for NMFS-approved experiments. If the water quality criteria identified in D-1641 were not met, and the Knights Landing Catch Index (KLCI) or Sacramento Catch Index (SCI) are less than three fish per day, the gates could be opened until the water quality criteria are met, then closed within 24 hours of compliance. If the KLCI or SCI were greater than 3 fish per day, then the Delta Operations for Salmonids and Sturgeon (DOSS) working group would review the monitoring data and make recommendations to NMFS and

WOMT for gate operations. From December 15 through January 31, the gates are closed except for permitted experiments (maximum of 5 days of gates in the open position) with NMFS approval for ESA compliance. COS procedures also permitted a one-time gate opening between December 15 and January 5 for up to 3 days, upon NMFS concurrence, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions. The DCC gates were to be operated such that the gates were opened one hour after sunrise to one hour prior to sunset, then return to full closure. During this period of gate openings, Reclamation and DWR were required to reduce exports down to the minimum health and safety level (1,500 cfs combined exports).

Under the proposed operations scenario, the DCC gates may potentially be opened more frequently (twice) after December 15 and for a longer period of time (up to 5 days each) than allowed under COS conditions. In addition, the opening of the gates may be determined by reaching a water quality "concern level" based on modeling outputs, rather than an actual exceedance of the water quality criteria required in D-1641. However, DCC opening will only occur when drought conditions are observed (defined during the May 21, 2019 consultation meeting as "fall inflow conditions are less than 90 percent of historic flows" and clarified in the June 14, 2019 PA; Appendix A3) and modeling shows that DCC opening will avoid exceedance of a water quality concern level. This joint condition is expected to occur in less than 1 in 10 years, and Reclamation and DWR will coordinate with USFWS, NMFS and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements.

From February 1 through May 20, the gates are proposed to remain closed to protect listed fish. This action parallels the actions required by D-1641. From May 21 to June 15, the gates will be closed for 14 days to provide protection for listed fish consistent with D-1641 criteria. From June 16 through September 30, the gates are proposed to remain open, unless water quality criteria for Delta outflows or electrical conductivity exceedances in the lower Sacramento River require the gates to close to alleviate these water quality concerns.

2.5.5.3.3.1 Sacramento River winter-run Chinook salmon

The timing of observations of natural (i.e., non-clipped fish) juvenile winter-run Chinook salmon captured in the Sacramento trawl (Sherwood Harbor) will serve as a proxy for their presence in the vicinity of the DCC gates (Table 2.5.5-11). For the period of October 1 to November 30, few natural juvenile winter-run Chinook salmon are observed in the catch of the Sacramento Trawl. On average, the date of the first observation of natural juvenile winter-run Chinook salmon for the period covering brood years 1994 to 2017 is December 5, the median date of the first observation of natural winter-run Chinook salmon in the trawl for this period of time is November 25. The earliest date of the first appearance of natural winter-run Chinook salmon in the Sacramento trawl is September 10 (1998 – a wet year) and the latest date for the first appearance of a natural juvenile winter-run Chinook salmon is March 3 (2016 – a drought year). From December 1 through January 31, approximately 50 percent of the natural juvenile winterrun Chinook salmon population has moved past the Sherwood Harbor location into the vicinity of the DCC gates. The average date for 50 percent passage is February 1, with the median date of February 13, for the period of 1994 to 2017. During the period of February 1 to May 20, when the gates are closed, the remainder of the natural juvenile winter-run Chinook salmon cohort has passed through the Sherwood Harbor location. The average last date of the observation of natural juvenile winter-run Chinook salmon in the trawl is March 31, with the median date of the last

observation being slightly later on April 9. Typically, no observation of natural juvenile winter-run Chinook salmon occurs from May 21 to September 30. Approximately 30 percent to 40 percent of these emigrating juveniles are expected to enter Sutter and Steamboat sloughs (Perry et al. 2010) and will avoid the location of the DCC gates. The majority of downstream emigrating fish (60-70 percent) are expected to stay in the main stem of the Sacramento River, and encounter the location of the DCC gates during their downstream migration. Hatchery produced winter-run Chinook salmon from the Livingston Stone National Fish Hatchery are typically released into the upper Sacramento River in early to mid-February and would arrive in the Delta after the DCC gates are closed for the period from February 1 through May 20.

Adult winter-run Chinook salmon are expected to start moving into the vicinity of the DCC gates starting in November and continue migrating past the DCC gate location through June with a peak presence from February to April. A flow of 400 cubic meters per second (14,126 cfs) or more on the Sacramento River is associated with a spike in catch of winter-run Chinook salmon at the Knights Landing rotary screw trap monitoring location (del Rosario et al. 2013), Figure 2.5.5-26).

Most adult winter-run Chinook salmon are expected to remain in the main channel of the Sacramento River during their upstream migration. However, some fish may use alternate routes to move upstream. These include the channels of Sutter and Steamboat sloughs to the north of the main stem Sacramento River channel, which would avoid the location of the DCC gates, as well as channels from the south, such as Georgiana Slough, which reconnects with the main stem Sacramento River downstream of the DCC gate location. During the period from November through January, when adult winter-run Chinook salmon are expected to be migrating upriver, the gates may be either open or closed, depending on water quality conditions and the presence of juvenile listed fish (winter-run and yearling spring-run Chinook salmon). When the DCC gates are closed, any false attraction flows through the DCC into the Mokelumne River system will likely be minimized. Conversely, when the gates are open during this period of time, false attraction flows from the main stem Sacramento River will flow into the Mokelumne River system and potentially attract adult winter-run Chinook salmon into the system from the San Joaquin River main stem. From February 1 through May 20, the DCC gates are closed and there should be no false attraction flows to encourage straying into the Mokelumne River system. From May 21 through the end of the adult winter-run Chinook salmon migration (June), the gates may be either closed or open. This may encourage straying in any late migrating adult winter-run Chinook salmon encountering the open gate condition.

2.5.5.3.3.2 CV spring-run Chinook salmon

The timing of observations of natural juvenile young-of-the-year (YOY) CV spring-run Chinook salmon captured in the Sacramento trawl (Sherwood Harbor) will serve as a proxy for their presence in the vicinity of the DCC gates (Table 2.5.5-12). For the period of October 1 to November 30, very few natural YOY CV spring-run Chinook salmon juveniles are observed in the catch of the Sacramento Trawl. On average, the date of the first observation of threatened natural YOY juvenile spring-run Chinook salmon for the period covering brood years 1994 to 2017 is December 29, the median date of the first observation of CV spring-run Chinook salmon in the trawl for this period of time is December 13. The earliest date of the first appearance of a natural YOY CV spring-run Chinook salmon in the Sacramento trawl is November 23 (2016 – a below normal year) and the latest date for the first appearance of a natural YOY CV spring-run

Chinook salmon juvenile is February 16 (2000 – an above normal year). From December 1 through January 31, less than 5 percent of the natural YOY juvenile CV spring-run Chinook salmon population has moved past the Sherwood Harbor location into the vicinity of the DCC gates. The average and median date for 50 percent passage is April 11, for the period of 1994 to 2017. During the period of February 1 to May 20, when the gates are closed, nearly all of the remaining YOY juvenile CV spring-run Chinook salmon population has passed through the Sherwood Harbor location, with very few individuals observed after May 20. On average, by April 27, 95 percent of the juvenile CV spring-run Chinook salmon population has moved past the Sherwood Harbor trawl location. The average date of the last observation of natural YOY juvenile CV spring-run Chinook salmon in the trawl is May 15, with the median date of the last observation being slightly earlier on May 11. Historically, very few natural YOY juvenile spring-run Chinook salmon are observed in the trawl during the period of May 21 to June 15, and essentially none from June 16 to September 30.

Hatchery-produced spring-run Chinook salmon from the Feather River Fish Hatchery are typically released in the spring in March and April, and normally would encounter the DCC gates when they are closed. There is the potential that if fish where slow in migrating downstream from their upstream releases, they may encounter the gates when they are opened periodically between May 21 and June 15.

An alternate life history strategy for CV spring-run Chinook salmon is to emigrate as yearlings during the fall and early winter after over summering in rivers and stream upstream of the Delta where conditions are suitable for their survival (i.e., Mill Creek, Deer Creek, and other Sacramento River tributaries supporting spring-run spawning). Typically, these fish emigrate as much larger fish than juvenile YOY spring-run Chinook salmon, and are thus less likely to be observed in the trawls and other monitoring actions due to their ability to avoid them. Yearling spring-run Chinook salmon are expected to enter the Delta after precipitation events in the upper Sacramento River basin increase flows in the tributaries and the mainstem Sacramento River and stimulate the yearling spring-run to start emigrating downstream. This may occur as early as October and extends through January and February. These fish would likely encounter the open DCC gates prior to December 1, and anytime the gates are opened from December 1 through January 31 for water quality issues.

Of the fish moving downstream in the mainstem Sacramento River, approximately 30 percent to 40 percent of these emigrating juveniles are expected to enter Sutter and Steamboat Sloughs (Perry et al. 2010) and will avoid the location of the DCC gates. The majority of downstream emigrating fish (60-70 percent) are expected to stay in the main stem of the Sacramento River, and encounter the location of the DCC gates during their downstream migration.

Adult CV spring-run Chinook salmon in the Sacramento River are expected to start moving into the vicinity of the DCC gates starting in January and continue migrating past the DCC gate location through June with a peak presence from February to April. Adult CV spring-run Chinook salmon are expected to encounter the DCC gates in a similar fashion and timing to that already described for adult winter-run Chinook salmon.

2.5.5.3.3.3 CCV Steelhead

The timing of observations of natural juvenile CCV steelhead captured in the Sacramento trawl (Sherwood Harbor) will serve as a proxy for their presence in the vicinity of the DCC gates

(Table 2.5.5-13). For the period of October 1 to November 30, very few juvenile CCV steelhead have been observed in the catch of the Sacramento Trawl. On average, the date of the first observation of juvenile CCV steelhead for the period covering brood years 1998 to 2017 is January 16, the median date of the first observation of CCV steelhead in the trawl for this period of time is January 15. The earliest date of the first appearance of CCV steelhead in the Sacramento trawl is January 2 (2003 – an above normal year) and the latest date for the first appearance of a steelhead juvenile is January 31 (2013 – a dry year). From December 1 through January 31, less than 10 percent of the natural juvenile CCV steelhead population has moved past the Sherwood Harbor location into the vicinity of the DCC gates. The average date for 50 percent passage is February 18, for the period of 1998 to 2017. The median date for 50 percent passage is February 16. During the period of February 1 to May 20, when the gates are closed, nearly all of the juvenile CCV steelhead population has passed through the Sherwood Harbor location. On average, by April 18, 95 percent of the juvenile CCV steelhead population has moved past the Sherwood Harbor trawl location. The average date of the last observation of juvenile CCV steelhead in the trawl is July 1, with the median date of the last observation a month earlier on June 2. Historically, very few juvenile CCV steelhead are observed in the trawl during the period of May 21 to June 15, and essentially none from June 16 to September 30.

Hatchery-produced steelhead are typically released in January and February, but may be released as early as mid-December and as late as April and May. Therefore, hatchery steelhead may encounter the DCC gates if they are opened in December or January for water quality issues.

Using the assumption that juvenile CCV steelhead will distribute into different river channels in a similar proportion as do juvenile Chinook salmon, approximately 30 to 40 percent of these emigrating juvenile CCV steelhead are expected to enter Sutter and Steamboat Sloughs (Perry et al. 2010) and will avoid the location of the DCC gates. The majority of downstream emigrating fish (60-70 percent) are expected to stay in the main stem of the Sacramento River, and encounter the location of the DCC gates during their downstream migration.

Adult CCV steelhead begin to migrate through the lower Sacramento River starting in July and continue through late fall, with a secondary peak occurring in late spring (presumably adults returning downstream as kelts). For most of the upstream migratory period, 90 percent of the adult CCV steelhead will encounter the DCC gates when they are open (July through November). From December through January, an additional 5.5 percent of migrating adults will encounter the gates in a primarily closed position, but may also encounter them in an open position if water quality is a concern. Less than 5 percent of the population will migrate during the February 1 through May 20 period when the gates are closed and the May 21 through June 15 periods when the gates are typically closed half of the time.

2.5.5.3.3.4 sDPS of North American Green Sturgeon

Both adult and juvenile sDPS green sturgeon are expected to be within the waters of the Delta year-round. Individual sDPS green sturgeon may encounter the DCC gates in multiple configurations as fish may hold and rear in the vicinity of the gates or encounter it as they move upstream and downstream during their behavioral movements. Adult sDPS green sturgeon are likely to encounter closed DCC gates during their upstream spawning migration in winter and early spring, but encounter open gates during their downstream migration in summer and fall following spawning. Juvenile sDPS green sturgeon rearing in the Delta may encounter the gates

year round in an open position (typically mid-June through September), intermittently closed (October and November), or in a closed position (December through mid-May).

2.5.5.3.4 Assess Response of Species to the Proposed DCC Gate Operations

The DCC can divert a significant proportion of the Sacramento River's water into the interior of the Delta. The DCC is a controlled diversion channel with two operable radial gates. When the gates are fully open, up to 6,000 cfs of water to pass down the DCC into the North and South Forks of the Mokelumne River in the central Delta (Low and White 2006). During the periods of winter-run Chinook salmon emigration when the DCC gates are proposed to be operational (*i.e.*, October to January) through the lower Sacramento River, approximately 40 percent of the Sacramento River flow (as measured at Freeport) can be diverted into the interior of the Delta through the DCC and Georgiana Slough when both gates are open. When the gates are closed, approximately 15 to 20 percent (as measured at Freeport) of the Sacramento River flow is diverted down the Georgiana Slough channel¹³.

The operations of the gates affect the flow conditions surrounding the junction of the DCC with the main stem Sacramento River and create complex hydrodynamic interactions as a result. Operations of the DCC gates create the following stressors related to changes in flow conditions, exposure to predation, and increased risk of straying or delayed migration:

- fish routing into various migratory pathways,
- alterations to transit times related to routing and alterations in flow(Horn and Blake 2004),
- increased risk to predation due to routing and increased transit times,
- increased risk to entrainment at the CVP and SWP export facilities, and
- creation of false attractant flows through the open DCC gates.

2.5.5.3.4.1 Routing

As acoustic-tagged Chinook salmon migrate downriver in the mainstem Sacramento River, fish have the opportunity to be diverted into alternative migratory routes. At the junctions of Sutter and Steamboat sloughs, approximately 30-40 percent of the migrating fish in the mainstem Sacramento River were detected moving into these routes, leaving approximately 60-70 percent of the migrating fish to move downstream towards the location of the DCC gates. When the DCC gates are open, juvenile fish moving within the main stem of the Sacramento River adjacent to the DCC junction may be entrained into the open channel and pass downstream into the Mokelumne River system and subsequently into the waterways of the interior Delta. Numerous acoustic tagging studies have confirmed that when the gates are open, a substantial proportion of juvenile fish are routed into the DCC channel (Newman and Brandes 2010, Perry et al. 2010, 2012, Romine et al. 2013). The proportion of acoustically-tagged Chinook salmon entrained into the Delta interior varied over the years. Perry et al. (2010) found that for studies in 2006 and 2007, when the DCC gates were open, 38.7 percent of the fish present in the main stem Sacramento River at the DCC junction (the 60 to 70 percent that were left in the mainstem Sacramento River downstream of Sutter and Steamboat slough junctions) were entrained into the DCC and 16.1 percent were entrained into Georgiana Slough. When the DCC gates were closed,

¹³ Instantaneous percentages can be much higher depending on the interaction of river flow and tidal flow as describe in Horn and Blake (2004).

15 to 20 percent of the fish in the Sacramento River present at the Georgiana Slough junction were entrained into the Georgiana Slough route. Of the fish that were not entrained into the interior Delta, 45.2 percent remained in the Sacramento River when the DCC gates were open, and nearly twice that percentage (80.0 to 85.0 percent) remained in the main stem of the Sacramento River when the DCC gates were closed. For studies conducted in 2008-2009, Romine et al. (2013) reported that the percentage of fish entering the DCC junction from the Sacramento River when the gates were open ranged between 13.6 and 66.7 percent with an overall average of 47 percent. For studies conducted in 2009-2010, Perry et al. (2012) reported that of fish present in the Sacramento River/ DCC junction when the gates were open, 20 percent of those fish entered the DCC, consistent with previous studies in 2007-2008. When the DCC gates are closed, more fish are entrained into the Georgiana Slough route because more fish remain in the Sacramento River main stem past the DCC junction. However, the proportion of fish that remain in the Sacramento River below both junctions (DCC and Georgiana Slough) into the interior Delta typically increases when the DCC gates are closed.

2.5.5.3.4.2 Transit times

Fish that enter the interior Delta through the open DCC gates or Georgiana Slough will have a longer migratory route than fish that emigrate through either the main stem Sacramento River or Sutter and Steamboat sloughs. Longer migratory routes would be expected to have lower survival rates in part due to longer transit times to the western Delta (Chipps Island), exposure to the effects of the export facilities in the southern Delta, and a prolonged exposure period to predators along these migratory routes (Perry et al. 2012). Perry et al. (2012) examined survival rates for unit distance travelled in the Delta and indicated that mortality rate per kilometer travelled actually increased as fish travelled from the upper Delta to the lower Delta, becoming the greatest in the tidal zone. The greatest decline in survival was observed for fish entering the interior Delta and travelling through the main stem San Joaquin River from the mouth of the Georgiana Slough/ Mokelumne River complex to Chipps Island, a region of increased tidal influence.

NMFS expects that environmental conditions that would require the opening of the DCC gates during the November through January period of juvenile Chinook salmon and steelhead emigration would be associated with lower river inflows from the Sacramento River and San Joaquin rivers, leading to the reduced water quality conditions that would necessitate the gate openings. Low flow conditions in the main stem Sacramento River would increase transit times within the region's channels leading to the DCC junction. Opening the gates would allow fish to enter the Delta interior under low flow conditions, leading to a longer migratory route with increased transit times and lower survival. It would also exacerbate the transit times for fish remaining in the main stem Sacramento River due to a smaller volume of water remaining in that channel after passing the DCC junction with the open gates. The reduction in flow in the main stem Sacramento River coupled with the open DCC gates would alter the local hydrodynamics surrounding the junctions of the DCC and Georgiana Slough, potentially leading to higher cumulative levels of entrainment into the Delta interior with the associated lower levels of survival for salmonids (Perry et al. 2015, Plumb et al. 2016). These changes in local hydrodynamics are discussed below.

2.5.5.3.4.3 Influence of local hydrodynamics related to flow

Perry et al. (2015) and Plumb et al. (2016) found that there is a tidal-flow threshold for entrainment into the interior Delta. When flows in the Sacramento River upstream of the DCC junction were less than approximately 12,000 cfs, flood tides caused the lower portions of the Sacramento River to reverse direction during flood tides, but not at flows above this threshold. Reverse flows during flood tides increased the amount of flow entering the DCC and the probability of fish being entrained into the Delta interior via that route. Fish that arrived at the DCC junction during ebb tides had a lower entrainment probability into the DCC route. In contrast, fish that arrived during flood tides with flow reversal had a high probability of entrainment into the delta interior via the open DCC gates. Perry et al. (2018) modelled the interacting influences of river flows and tides on travel time, routing, and survival of juvenile late-fall Chinook salmon migrating through the Delta. Their modelling found that travel time was inversely related to river inflows in all river reaches examined. Survival was positively related to river inflow only in the reaches that transitioned from bi-directional (tidal) to unidirectional (riverine) with increasing river inflows. The researchers also found that the probability of entering alternative routes to the interior delta declined with increasing river inflows. Thus, by keeping river flows elevated in the main stem of the Sacramento River, such as by keeping the DCC gates closed, tidal fluctuations downstream of the junction are dampened in all but the most tidal reaches. Perry et al. (2018) found evidence that operating the DCC gates, which removes water from the Sacramento River channel, was associated with lower survival in the reaches of the Sacramento River downstream of the DCC junction. In addition, the modelling showed that as flow in the main stem Sacramento River increases, the probability of entering Georgiana Slough, when the DCC gates are closed, decreased by 16 percent. Likewise, an open DCC gate reduces the percentage of fish entering Georgiana Slough, but this is in part due to less fish being present at the Georgiana Slough junction to be entrained, since there is an increased percentage of fish that went into the DCC route through the open gates and into the interior Delta. The cumulative percentage of fish that are entrained into the Delta interior (DCC plus Georgiana Slough) was 15 percent higher than the probability of entering Georgiana Slough alone when the gates are closed.

2.5.5.3.4.4 Survival related to transit routes and predator exposure

Perry et al. (2010), Perry et al. (2012), Perry et al. (2013), and Romine et al. (2013) have stated that survival is lowest for Chinook salmon entrained into the Delta interior. The interior Delta routes are longer than the routes using the Sacramento River or Sutter/Steamboat sloughs and, therefore, would expose migrating Chinook salmon to more predation risk than shorter routes (Perry et al. 2012). Cumulative survival over a given route is a product of migration distance or migration rate and mortality per unit distance, and interacts to affect total survival for each route. The acoustic tag studies by Perry et al. (2012), Perry et al. (2018) found that not only were the interior Delta routes longer, but they had higher mortality rate per unit distance travelled than other routes through the Delta. This finding indicates that even if the migration routes through the Delta interior were the same distance as other routes, overall survival would still be less due to the higher mortality rate per unit distance. Higher mortality rates per unit distance combined with longer migration distance provides one mechanism for explaining the consistently lower survival for fish entering the interior Delta relative to the Sacramento River. In a tidal environment, where prey migration speeds are likely slower relative to predator swimming

speeds, such that multiple encounters with predators are possible, the probability of survival is dependent on travel time through the reach and not necessarily the distance travelled. In the tidal reaches of the Delta, salmon movement patterns shift from downstream-only directed movements to both upstream and downstream movements. Thus, in the lower reaches of the Delta a fish may pass through a given reach more than once as they move upstream with the flood tide and then back downstream on the ebb tide, increasing not only the time it takes to move through this reach, but also increasing the absolute distance travelled. This could increase the number of predator encounters relative to the length of the reach, therefore increasing mortality rates per a unit distance travelled.

In addition, as fish are moved back and forth in a given tidally-influenced river channel reach, they may be exposed multiple times to any waterway junctions present within a given reach. With each passage past the junction, the probability of routing into the alternate route increases. If that route leads into habitat that has less survival potential, such as the interior Delta via Georgiana Slough, the overall survival probability for that individual fish is reduced, and hence the overall survival fraction of the population may be reduced with each additional individual that is routed into the less favorable migratory route. There have been recent efforts to test alternative technologies to create non-physical and physical barriers at such junctions that dissuade movement into those junctions (California Department of Water Resources 2012, 2015, 2016) as a requirement of the NMFS 2009 Opinion, RPA Action IV.1.3 (National Marine Fisheries Service 2009b). DWR has tested a bioacoustics barrier and a floating fish guidance structure in the Georgiana Slough junction with the mainstem Sacramento River under various flow conditions. Results indicated that at certain flow ranges the barriers could be effective at keeping emigrating salmonids in the mainstem of the Sacramento River and reducing the fraction that could enter the Georgiana Slough route.

2.5.5.3.4.5 Increased risk of entrainment at the CVP and SWP fish salvage facilities

Salmonids that are entrained through the open DCC gates and into the Delta interior also have a greater probability of eventually being entrained at the SWP and CVP fish salvage facilities (Low and White 2006, Newman and Brandes 2010) than fish that remain in the Sacramento River migratory route. Fish that exit from the downstream end of the DCC routes through the Delta interior enter the tidally-influenced lower San Joaquin River main stem. Tidal forcing can redirect fish into the channels of Old and Middle rivers, where the influence of the exports is manifested as net reverse flows towards the export facilities.

2.5.5.3.4.6 Increased risks of straying or delayed migration due to DCC gate operations

In situations where the DCC gates are open, additional flows from the Sacramento River enter the Delta interior via the Mokelumne River system. Flows from the Sacramento River into this waterway system may provide false olfactory cues for adult Chinook salmon, steelhead, and green sturgeon. Acoustic tracking studies by CDFG (CalFed 2001) indicated that adult fall-run Chinook salmon may make extensive circuitous migrations through the Delta before finally ascending either the Sacramento or San Joaquin rivers to spawn. These movements included "false" runs up the main stems with subsequent returns downstream into the Delta before their final upriver ascent. Tagged fish moved up to the location of the DCC gates and either passed through the open gates or were blocked by closed gates, forcing them to return downstream and find another route to the main stem Sacramento River to continue their upstream migration.

2.5.5.3.5 Risk to Sacramento River winter-run Chinook salmon

Juvenile winter-run Chinook salmon in the Sacramento River can start migrating into the vicinity of the DCC gates starting as early as September or October based on the earliest dates for recorded captures in the Sacramento trawl, but more typically are not observed until November. As indicated in Table 2.5.5-11, the average first date of observation in the Sacramento trawl is in late November or early December. During the October 1 to November 30 period, the DCC gates may be closed to protect pulses of early emigrating juvenile winter-run Chinook salmon if the KLCI or SCI triggers are exceeded. This typically occurs when the first major precipitation event occurs in the fall or early winter period and Sacramento River flow exceeds about 14,000 cfs at Wilkins Slough (del Rosario et al. 2013). This initial migration event has been shown to include over 50 percent of the annual winter-run Chinook salmon population sampled at Knights Landing (del Rosario et al. 2013). If flows exceed approximately 20,000 to 25,000 cfs at Freeport, then the DCC gates are closed for flood protection in downstream river reaches. This would also be protective of winter-run Chinook salmon or other listed salmonids moving downstream under the elevated flows. From December 1 through January 31, the DCC gates are normally closed, but may be opened for water quality concerns. By the end of January, typically 50 percent of the juvenile winter-run Chinook salmon for that year has entered the Delta and is in the vicinity of the DCC gates. Closure of the gates during this period will protect a substantial proportion of the cohort. If gates are opened (up to two times for 5 days each) for water quality concerns, then a substantial proportion of the juvenile winter-run Chinook salmon cohort may be at risk of entrainment into the DCC waterway for the less than 1 in 10 years the gates are expected to be open between December 1 and January 31. As described above, these fish would enter the migratory routes through the Delta interior and be subject to a much lower rate of survival due to multiple factors previously explained. In addition, reduced flows downstream of the open DCC in the main stem Sacramento River would be expected to reduce survival due to increased transit times and the potential to be entrained into Georgiana Slough.

Water quality concerns typically arise during dry years, when salinity criteria are in danger of being exceeded at key locations in the Delta (Table 2.5.5-10). During dry years, juvenile winterrun Chinook salmon downstream migration is usually delayed until January or February, when winter storms first arrive. The delay in juvenile winter-run Chinook salmon entering the Delta region adjacent to the location of the DCC gates may ameliorate the increased potential risk due to the need to open the gates for water quality concerns during the December through January period when drought conditions are observed. After February 1, the gates are closed until May, when all of the juvenile winter-run Chinook salmon have characteristically exited the Delta. Closure of the DCC gates from February 1 to May 20 protects the last 50 percent of the population that is entering the Delta from entrainment into the interior Delta via the DCC route.

Adult winter-run Chinook salmon start entering the Delta in November and continue through June with a peak presence from February to April. Based on the proposed gate operations for the DCC, adult fish will typically encounter open gates in November when the first fish start to arrive. Upstream passage into the main stem Sacramento River should not be impeded, even though fish have strayed into the Mokelumne River system. After December and through the end of January, the DCC gates will typically be closed, and adult winter-run Chinook salmon are unlikely to be attracted into the Mokelumne River system due to the false attraction of Sacramento River water coming through the system in substantial amounts. This will change, however, if the gates need to be opened for water quality purposes. Under this scenario, when the

gates are open, there is a risk of adult winter-run Chinook salmon being attracted into the Mokelumne River system by the additional flow of Sacramento River water through the gates, though this effect is expected in less than 1 in 10 years. When the gates are closed after 5 days, these fish then run the risk of being caught behind the closed gates and their upstream migration delayed until they drop back downstream and find an alternative route into the Sacramento River watershed. Since adult Chinook salmon have been observed to make several movements upstream and downstream in the Delta waterways before finally moving upstream towards their spawning grounds, the temporary delay should not cause any permanent physiological impairment.

2.5.5.3.6 Risk to CV spring-run Chinook salmon

Natural yearling CV spring-run Chinook salmon are expected to enter the Delta in late fall and early winter (late October through January). Natural juvenile CV spring-run Chinook salmon are expected to be present in the northern Delta region from December through May with a peak presence in April. By the end of January, about 5 percent of a given juvenile CV spring-run Chinook salmon cohort has entered the Delta region near the DCC gates (Table 2.5.5-12), with the first demonstrable arrival of juveniles occurring in mid- to late-December. Based on the proposed operations of the DCC gates, up to 5 percent of the juvenile cohort will be exposed to the potential opening of the gates (December through January) in less than 1 in 10 years, which in those years will create an elevated risk of entraining fish into the Delta interior, where survival is reduced compared to remaining in the Sacramento River migratory route. After February 1, when the gates are closed through May 20, approximately 95 percent of the juvenile CV springrun Chinook salmon cohort will enter the Delta and move through the Sacramento River adjacent to the DCC gates. The effects of operations of the DCC gates for water quality concerns should be similar to that already described for juvenile winter-run Chinook salmon and occur only in drier conditions when exceedances of salinity thresholds at key Delta locations are forecasted to occur. Thus, the overall risk of entraining juvenile CV spring-run Chinook salmon into the interior Delta through the DCC gates is low (~5 percent of the cohort).

Adult CV spring-run Chinook salmon enter the Delta starting in starting in January and continue migrating past the DCC gate location through June with a peak presence from February to April. Therefore almost all of the adult migratory period will occur when the gates are closed. There is a small probability that some adults will enter the Delta when the gates are open for water quality purposes in January, and be attracted to migrate up through the Mokelumne River system to the open DCC gates, but these impacts are expected in less than 1 in 10 years. This should not impede migration. As previously explained for adult winter-run Chinook salmon, any adults in the DCC when the gates close following a water quality operation are expected to drop back downstream and re-enter the Sacramento River through a different route. There is no expectation that this minor delay will cause any adverse physiological impacts to adult CV spring-run Chinook salmon.

2.5.5.3.7 Risk to CCV Steelhead

Wild juvenile CCV steelhead are expected to be present in the Sacramento River near the DCC gates year-round, as observations of fish captured in the Sacramento River trawl have occurred in most months. However, few fish are actually observed from May through the following fall. Starting in mid-January, observations of juvenile CCV steelhead begin to increase in the

Sacramento River trawl at Sherwood Harbor. By the end of January and into early February, approximately 25 percent of the current year's juvenile CCV steelhead passage through this region has occurred. Therefore, this fraction of the annual juvenile CCV steelhead population is at risk for being entrained into the interior Delta through open DCC gates following any water quality associated actions (expected to occur in less than 1 in 10 years), although the actual fraction present at the time the gates are physically open is expected to be quite less. Exposure of the juvenile CCV steelhead is expected to result in entrainment into the Delta interior through the open gates, and reductions in survival similar to that already described for Chinook salmon is anticipated.

Adult CCV steelhead migrating into the Sacramento River basin will be present in the Sacramento River adjacent to the DCC gate location during their upstream spawning migration primarily from July through November, peaking in September and October. There is a much smaller peak in February, potentially consisting of kelts returning downstream after spawning from the Sacramento River basin. Therefore, most of the adult CCV steelhead population migrating upstream will encounter the DCC gates in an open position from July through November. Adult CCV steelhead from the Sacramento River basin populations will be able to pass upstream either from the main stem Sacramento River migratory route, or from the Mokelumne River system through the open DCC gates if they had strayed into the San Joaquin River system. Kelts returning downstream in late winter/early spring will pass by the DCC gates while they are closed and remain in the main stem of the Sacramento River. Remaining in the main stem channel will allow fish to have shorter transit times to the lower tidal Delta and follow a more direct route to the estuary.

2.5.5.3.8 Risk to sDPS Green Sturgeon

Little information exists regarding the behavior of juvenile sDPS green sturgeon and their risk of entrainment through the DCC gates when open. Acoustically tagged juvenile sDPS green sturgeon have been detected entering the DCC when the gates are open during their downstream movements. Furthermore, the changes in survival for juvenile sDPS green sturgeon using different routes through the Delta is unknown. The fact that juvenile sDPS green sturgeon may spend an extended period of time rearing in the waterways of the Delta (months to 2-3 years) complicates assigning a survival rate to any given potential migratory route.

Adult sDPS green sturgeon may be impacted by the potential for delay behind the closed gates during their upstream migration. Acoustic tagging efforts to date indicate that tagged fish typically move upriver through the main stem of the Sacramento River in the Delta and not within the interior delta waters adjacent to the downstream channel of the DCC. However, observations of adult sDPS green sturgeon in areas such as the Yolo Bypass following inundation indicate that adults may follow alternate routes if flows and olfactory cues from the upper Sacramento River are present. If the DCC gates are open, some adult migrants may inadvertently enter the downstream sections of the Mokelumne River system and continue upstream in this system to the location of the DCC gates, following the scent of the Sacramento River inflow. If the gates are then subsequently closed before they reach the location of the DCC gates, they would be subject to migrational delays during their spawning runs below the closed DCC gates. In this situation, adult sDPS green sturgeon could drop back downstream and find an alternative route back to the mainstem of the Sacramento River to continue their spawning migration upriver.

2.5.5.3.9 Delta Cross-Channel Gate Improvements

The DCC radial gates are older structures which require operators to be physically onsite to manually operate the gates in order to open or close them. Increased use could result in the radial gates breaking in either the open or closed positions. Improvements to the DCC would allow greater operational flexibility, faster, automated operations, and increased gate reliability. Without these improvements, the risk of gate failure increases which could lead to higher rates of entrainment of winter-run Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead should the gate fail in an open or partially open position. Further, improved DCC operational flexibility along with improved biological and physical monitoring would likely minimize salmonid routing into the interior Delta with its associated greater level of mortality.

Reclamation proposes to make renovations to the DCC gate structure and operating mechanisms during the summer seasonal work window when few winter-run Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead are expected to be exposed to construction improvements. Future operations of the gates may include diurnal openings with nocturnal closures to take advantage of salmonid migratory behavior. However not enough information has been presented in the PA (February 5, 2019; Appendix A1) description to conduct an effects analysis for this form of future operations of the DCC gates. This PA component will be considered as a programmatic consultation.

2.5.5.4 North Bay Aqueduct Operations

2.5.5.4.1 Physical Description of the Barker Slough North Bay Aqueduct Infrastructure

The North Bay Aqueduct (NBA) is part of the SWP. The Barker Slough Pumping Plant (BSPP) diverts water from Barker Slough into the NBA for delivery to the Solano County Water Agency (SCWA) and the Napa County Flood Control and Water Conservation District (Napa County FC&WCD) (NBA entitlement holders). The NBA is an underground pipeline that runs from Barker Slough in the northern Delta to Cordelia Forebay, just outside of Vallejo. From Cordelia Forebay, water is pumped to Napa County, Vallejo, and Benicia. The NBA also serves Travis Air Force Base. The size of the pipeline varies from a diameter of 72 inches at Barker Slough, to 54 inches at Cordelia Forebay. Maximum pumping design capacity is 175 cubic feet per second (cfs) (pipeline capacity). During the past few years, daily pumping rates have ranged between 0 and 140 cfs. The current maximum pumping rate, as determined through testing of the existing pumps, is 142 cfs. The difference between the design maximum and the tested maximum is due to the physical limitations of the existing pumps. Growth of biofilm in a portion of the pipeline also limits the NBA ability to reach its full pumping capacity.

The NBA intake is located approximately 10 miles from the main stem Sacramento River at the end of Barker Slough. Each of the 10 NBA pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch that meets CDFW and NMFS fish screening criteria. This configuration is designed to exclude fish approximately 1 inch or larger from being entrained. The inlet bays tied to the two smaller pumping units have an approach velocity of about 0.2 feet per second (ft/s). The larger units were designed for a 0.5 ft/s approach velocity, but actual approach velocity is about 0.44 ft/s. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increased localized approach velocities ("hotspots" on the screen).

2.5.5.4.2 Deconstruct the Action

Water Diversion - DWR proposes to operate the NBA intake in the North Delta through the operation of the BSPP to deliver water to the NBA entitlement holders as has been previously done. Current pumping capacity is limited to 140 cfs due to the functional capacity of the existing pipeline at the facility and the capacity of the existing pumps. The proposed operations of the BSPP also includes a maximum 7-day average diversion rate that would not exceed 50 cfs from January 15 through March 31 of dry and critically dry years (per the current forecast based on D-1641) if larval Delta Smelt are detected at Station 716 during the annual Smelt Larval Survey.

Pumping is typically lower in the winter and early spring (December through April) than in the summer and fall (May through November) (Table 2.5.5-14 and Table 2.5.5-15) and DWR believes there will be no change in the pattern of pumping from what has occurred in the past. An additional pump is required to reach the pipeline design capacity of 175 cfs. The BSPP facility is equipped with a positive barrier fish screen designed and constructed to meet CDFW and NMFS fish screening criteria and DWR intends to maintain its function and compliance with the CDFW and NMFS fish screen criteria under the PA component. The BSPP facility entrains water from Barker Slough and surrounding waterbodies, including Campbell Lake, Calhoun Cut, and Lindsey Slough. It is approximately 10 miles upstream of the confluence of Lindsey Slough with Cache Slough. Due to the entrainment of water from the surrounding sloughs, the intake has the potential to entrain migrating salmonids and sDPS green sturgeon that may be present in the Cache Slough complex of channels, which includes waters discharging from the Yolo Bypass and Miners Slough.

NMFS makes the following assumptions regarding the operations of the BSPP and NBA under the PA (February 5, 2019; Appendix A1) component:

- Proposed operations will not change appreciably from historical operations at the facilities:
- Future export flows and volumes will remain consistent with historical operations; and
- Seasonal patterns of exports will remain consistent with historical patterns.

Sediment removal - Sediment accumulates in the concrete apron sediment trap in front of the BSPP fish screens and within the pump wells behind the fish screens. DWR proposes to continue sediment removal from the sediment trap and the pump wells as needed.

Aquatic weed removal – DWR proposes to remove aquatic weeds, as needed, from in front of the fish screens at BSPP. Aquatic weeds accumulate on the fish screens, blocking water flow, and causing water levels to drop behind the screens in the pump wells. The low water level inside of the pump wells causes the pumps to automatically shut off to protect the pumps from cavitation. Aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the BSPP pumps, will lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds will be transported to two aggregate base spoil sites located near the pumping plant.

2.5.5.4.3 Assess Species Exposure to Proposed Barker Slough Pumping Plant/ North Bay Aqueduct Operations

Listed salmonids may be present in the waterways adjacent to the BSPP, however several years of monitoring have not consistently captured any salmonids during the winter Delta smelt surveys (1996 to 2004) in Lindsey Slough or Barker Slough. Captures of juvenile Chinook salmon have occurred in the months of February and March and typically are only a single fish per net haul (CDFG Catch summary:

http://www.dfg.ca.gov/delta/data/nba/catchsummary.asp?type=species). Most juvenile Chinook salmon captured have come from Miners Slough, which is a direct distributary from the Sacramento River via Steamboat and Sutter sloughs. However, one fish was captured at site 721 in Barker Slough near the location of the BSPP (Figure 2.5.5-27 and Table 2.5.5-16). No steelhead or green sturgeon have been captured in the monitoring surveys from 1996 to 2004, the range of dates available on the CDFW website. Green sturgeon are assumed to occur in the waters of Cache Slough and the Sacramento ship channel as green sturgeon have been caught in these waters by sport fisherman.

Adult salmonids are assumed to be at low risk of impingement on the fish screens, and due to the lack of inflow to the channel are unlikely to be attracted upstream to the vicinity of the BSPP location during their spawning migrations. Adult green sturgeon may use the waters of the Cache Slough complex opportunistically while holding in the Delta, but like adult salmonids, are unlikely to be affected by the screens. A summary of the effects of the proposed North Bay Aqueduct Operations is provided in Table 2.5.5-62 in Section 2.5.5.13 Summary Tables of Stressors for each Project Component.

2.5.5.4.4 Assess Response of Species to the Proposed NBA Operations

During the winter period, exports from the BSPP are expected to remain low, ranging from a monthly average of 10.9 cfs in March to 29.5 cfs in January based on historical patterns for the past 10 years (2008 to 2018). From May to November, the average diversion flow ranges from a monthly average of 66.4 cfs in November to 91.4 cfs in August for the same 10-year period (Table 2.5.5-15). Monitoring by CDFW for the NBA larval fish survey indicates that some Chinook salmon have been observed at the most western monitoring location (site 721) in Barker Slough, but in general, observations of Chinook salmon are rare, and occur farther to the east near the confluence of Miners Slough with the Cache Slough complex. The low diversion rate during the period from December to April is unlikely to entrain fish from the lower reaches of the Cache Slough complex to locations adjacent to the BSPP Barker Slough. Even in May, the average monthly diversion rate is only ~71 cfs, with a range of 33 to 108 cfs. Even at the current maximum diversion rate of 140 cfs, the size of the channels in the Cache Slough complex would mute any flow towards the BSPP from the lower reaches of the Cache Slough complex.

The fish screens, which were designed to protect juvenile Delta smelt and meet the NMFS criteria for salmonids, should prevent entrainment and greatly minimize any impingement of fish against the screen itself. Furthermore, the location of the pumping plant on Barker Slough is substantially removed from the expected migrational corridors utilized by emigrating Chinook salmon and steelhead juveniles in the North Delta system. Green sturgeon may be present in the waters of Lindsey and Barker sloughs since they are present in Cache Slough and the

Sacramento Deepwater Ship Channel. Green sturgeon are expected to be fully screened by the positive barrier fish screen in place at the pumping facility.

Cleaning of the sediment that has accumulated in front of the fish screens may increase the risk of fish entrainment, depending on the method used. DWR did not describe the methodology to be used, but NMFS can make reasonable assumptions regarding this procedure. Using water jets to resuspend the sediments in front of the fish screens and then drawing this water through the screens will avoid any adverse impacts related to entrainment. In contrast, if a suction vacuum or hydraulic dredge is used to remove the sediment in front of the screens, then fish may be entrained into the suction hose or dredge head and deposited along with the sediment in the dredge spoils waste area. Removal of sediment behind the fish screens will not impact fish as the water is already screened and no listed fish should be present within the pump wells. If cleaning takes place at a time when listed salmonids or green sturgeon are unlikely to be present (i.e., summer with high ambient water temperatures), then the risk of exposure is greatly reduced or nonexistent.

Cleaning of the fish screen by removal of aquatic weeds and vegetation may harm fish if the grappling hooks or frame directly strike the fish, or if fish become entangled in the vegetation as it is being removed and is subsequently deposited in the waste pits to die. As previously stated, if vegetation removal occurs at times when listed salmonids or sDPS green sturgeon are unlikely to be present, then the risk of negative effects is greatly reduced due to avoiding any temporal overlap between the listed species and the weed removal action. This is the likely scenario, since aquatic weeds grow fastest during the warmer seasons, and elevated exports at the BSPP would draw the weeds into the fish screens during the summer and fall seasons when water diversions are greatest. At this time of year, it is unlikely that listed salmonids or green sturgeon would be present in these shallow waterways.

2.5.5.4.5 Risk to Listed Salmonids

The presence of listed salmonids (winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead) in the waters of Barker Slough appears unlikely based on the monitoring data available. If the fish are unlikely to be present in the vicinity of the NBA export pumps based on the one observation at site 721, then there is minimal likelihood of an increase in the encounter rates with the screens due to the diversion of water. Therefore, a minimal adverse effect from the NBA intake on juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead from the Sacramento River basin is expected. Furthermore, the fish screens are designed to avoid any entrainment or impingement of salmonids. Therefore, it is unlikely that any fish will be negatively impacted by being present near the screens during water diversions. In regards to sediment removal and aquatic weed removal, the likelihood of listed salmonids being present near the BSPP fish screens when these actions are being carried out is very low, particularly if these actions occur during the summer season when water temperatures are elevated. It is not expected that the PA components by DWR to operate the NBA will alter the current risks to listed salmonids.

2.5.5.4.6 Risk to Listed sDPS Green Sturgeon

For the same reasons described for listed salmonids, the risk of negative effects to sDPS green sturgeon is very remote. The fish screen is designed to protect Delta Smelt and salmonids and

will provide the same protection to juvenile sDPS green sturgeon. sDPS green sturgeon are unlikely to be affected by the cleaning of sediment or aquatic weeds. It is unlikely that they will be present at the fish screen location at any time and particularly during the summer when water temperatures are elevated, and therefore they are unlikely to be present when these cleaning operations are being implemented.

2.5.5.5 Contra Costa Water District – Rock Slough Operations

2.5.5.5.1 Description of the Contra Costa Water District/ Rock Slough Intake Infrastructure and Operations

The Contra Costa Water District (CCWD) diverts water from the Delta for irrigation and municipal and industrial (M&I) uses under its CVP contract, under its own water right permits and license issued by the SWRCB, and under CCWD's pre-1914 water right. The CCWD water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Rock Slough Fish Screen [constructed in 2011 under the authority of CVPIA 3406(b)(5)]; the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough Intake, Contra Costa Canal, and shortcut pipeline are owned by Reclamation, and operated and maintained by CCWD under contract with Reclamation. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD.

The Rock Slough Intake is located about four miles southeast of Oakley. Water is pumped west from Rock Slough through a positive barrier fish screen into the Contra Costa Canal using Pumping Plants #1 through #4. The fish screen at this intake was designed in accordance with the CVPIA and the 1993 USFWS Opinion for the Los Vaqueros Project to reduce take of fish through entrainment at the Rock Slough Intake and became operational in 2012. The 1.75-mmopening, 0.2 ft/s-approach-velocity fish screen installed at the Rock Slough intake is intended to prevent entrainment of listed fish, including juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead, into the Contra Costa Canal. The Contra Costa Canal is 48 miles long, CCWD's Contra Costa Canal Replacement Project replaces the 4-mile long, earthlined portion of the Contra Costa Canal between the Rock Slough Fish Screen and Pumping Plant #1 with a buried 10'-diameter concrete pipe. The remaining 44 miles of the Contra Costa Canal after Pumping Plant #1 are concrete-lined. The earth-lined portion of the Contra Costa Canal is subject to water quality degradation due to seepage into the canal from saline groundwater in the area, as well as seepage losses where the groundwater table is lower than canal water levels. Replacing the open channel with a buried pipe also eliminates evaporative losses. Removal of the open water facility also improves public safety, system security, and flood control, which are needed in light of the developing and planned urbanization in the vicinity. As of late 2018, approximately 3 miles of the earth-lined portion of the Canal has been replaced (from Pumping Plant #1 to the east) and the flood isolation structure near the fish screen has also been completed. Pumping Plant #1 has a permitted capacity to pump up to 350 cfs into the Canal. Diversions at Rock Slough Intake are typically taken under CVP contract or under CCWD's pre-1914 water right. CCWD diverts approximately 30 percent to 50 percent of its total annual supply through the Rock Slough Intake, depending upon water quality in a given year.

2.5.5.5.2 Deconstruct the Action

Reclamation is consulting on the ongoing operations of the Rock Slough Intake that diverts water from Rock Slough, through the Contra Costa Canal to the pumping plants near Oakley. CCWD diverts approximately 127 TAF per year in total through Rock Slough (30-50 percent of its total annual supply). Approximately 110 TAF is CVP contract supply. In winter and spring months when the Delta is relatively fresh (generally January through July), deliveries to the CCWD service area are made by direct diversion from the Delta.

Reclamation is not consulting on the biological opinions that govern CCWD's intakes and Los Vaqueros Reservoir, nor will this consultation amend or supersede those separate biological opinions. For the PA (February 5, 2019; Appendix A1) component in this consultation, CCWD's operations are consistent with the current implementation of the operational criteria specified in those separate biological opinions. Reclamation is requesting incidental take coverage for all water diverted at the Rock Slough Intake up to the maximum capacity of the intake (350 cfs) for the maximum annual diversion of 195 TAF. Diversions from 2008-2018 have been less than this (Figure 2.5.5-28).

2.5.5.5.3 Assess Species Exposure to Proposed CCWD Rock Slough Operations

Juvenile winter-run Chinook salmon are present from approximately December through June based on salvage records from the CVP/SWP fish salvage facilities (Table 2.5.5-17). The peak occurrence of juvenile winter-run Chinook salmon in the south Delta is from January through March.

Juvenile CV spring-run Chinook salmon are present in the South Delta in the vicinity of the CCWD diversions from January through June with peak occurrence from March through May (Table 2.5.5-18).

CCV steelhead may also be present in the waters of the South Delta from October through July, but have peak occurrence from late February through early April (Table 2.5.5-19).

Juvenile and adult sDPS green sturgeon are assumed to be present year-round in the Delta.

A summary of the effects of the proposed CCWD Rock Slough operations is provided in Table 2.5.5-63 in Section 2.5.5.13 Summary Tables of Stressors for each Project Component.

2.5.5.5.4 Assess Response of Species to the Proposed CCWD/ Rock Slough Operations

The positive barrier fish screen was completed and became operational in 2011. The screen is designed to meet both the NMFS and CDFW criteria for preventing salmonids from entrainment and impingement. The operation and maintenance of the fish screen is the subject of its own biological opinion with NMFS and has its own incidental take (National Marine Fisheries Service 2017e). The screen is located approximately 3.6 miles west of the junction of Old River with Rock Slough, and approximately 2.8 miles from the junction of Werner Cut with Rock Slough.

Listed salmonids can access the fish screen at the terminal portion of the Rock Slough channel from either the route leading from the junction with Old River, which is the most direct route, or by the more circuitous route through Werner Cut which connects with Indian Slough to the south (4.4 miles) and then eastwards to Old River just north of the Highway 4 Bridge (2.4 miles; total

distance 6.8 miles). Listed salmonids are known to occur in the Old River channel, and may come from both the northern direction (lower main stem San Joaquin River) or from the south via Middle and Old rivers. Fish that come from the north may originate in the Sacramento River basin, the Mokelumne River basin, the Cosumnes River basin or the San Joaquin River basin, based on observations of listed fish at the CVP/SWP fish salvage facilities. Fish that come from the south would generally originate from the San Joaquin River basin via the Head of Old River, but would have to escape entrainment at the CVP Tracy Fish Collection Facility or SWP's Clifton Court Forebay (CCF) to travel northwards towards Rock Slough. Fish migrating within the Old River channel would experience tidal forcing into and out of these channels twice daily. Once fish are pushed into the Rock Slough channel, and have moved past the junction between Rock Slough and Werner Cut, they would begin to experience the effects of water diversion by CCWD through their Rock Slough facilities. The Rock Slough channel is approximately 600 feet wide at its junction with Old River, then becomes narrower as it approaches the location of the fish screen. The final channel width is approximately 230 feet for the final approach to the fish screen, with a depth of about 10 feet, and is a dead end channel, terminating at the screen.

CCWD diverts water throughout the year, but not at consistent rates. Export rates are frequently much less than the permitted maximum (Figure 2.5.5-16). If the CCWD exports at its maximum permitted rate (350 cfs), the estimated average flow velocity in the terminal portion of the Rock Slough channel would be 0.15 feet per second (fps), based on a cross section of 2,300 square feet (230-foot width x 10-foot depth) and the equation Q (flow volume) = Area (channel cross sectional area) x velocity (average flow velocity). The magnitude of tidal flow would be likely be much greater in this channel compared to the velocity generated at the maximum export rate. The sustained swimming speed of a juvenile salmonid should be more than adequate to escape the 0.2 fps approach velocity of the screen and the ambient velocity in the channel created by the water diversion.

While listed fish are most likely able to volitionally escape the effects of the fish screen and avoid impingement, the diversion of water and the small increase in net velocity towards the intake canal may delay or inhibit their normal movements and migratory behavior. This would increase their transit time through this region of the south Delta. As previously described in the section regarding the effects of the DCC, and increases in transit times during migration, any increase in transit time has the potential to increase the risk of mortality. This increase is most likely related to an increase in the duration of exposure or the number of predators encountered by a migrating fish. For fish that increase their time remaining within the Rock Slough channel, the risk of exposure to predator increases. Rock Slough has habitat that is favorable to non-native predators such as striped bass in the open channel waters, and black bass along the channel shorelines. NMFS anticipates that any listed salmonids present in the Rock Slough channel would be more vulnerable to predation the longer it remained in those waters.

2.5.5.5.5 Risk to Listed Salmonids

The CCWD has conducted fish monitoring in the Rock Slough channel headworks and within the Contra Costa Canal at Pumping Plant #1 for several decades. Prior to the installation of the positive barrier fish screen (operational in 2011), monitoring efforts collected low numbers of Chinook salmon and steelhead at both the headworks location (adjacent to current fish screen location) and at Pumping Plant #1 downstream in the Contra Costa Canal (Table 2.5.5-20). Since the installation of the positive barrier fish screen in 2011, no salmonids have been

observed in fish monitoring behind the screens for the period of 2011 to 2018. The monitoring data from before the installation of the fish screen (1999 – 2011) would indicate that it is possible for salmonids to be present at the location of the fish screen on Rock Slough, but that they would present in low numbers. The potential for salmonids to occur in front of the fish screens during water diversions is anticipated to remain the same under current conditions. The more recent data for sampling behind the fish screen (2011-2018) indicate that the screens are functioning as designed, and listed salmonids are unlikely to pass through the screens during water diversions. This indicates that there is a negligible risk to listed salmonids of entrainment through the fish screens during water diversions. It is possible that some impingement may occur due to localized "hot spots" on the screen face developing when aquatic weeds clog the screen face, creating localized high approach velocity regions. The cleaning operations for the fish screen are designed to reduce or eliminate the potential for the creation of "hot spots' along the face of the fish screen.

For any listed salmonid present within the vicinity of the fish screens or within the Rock Slough channel leading up to the fish screens, the risk of predation is elevated the longer they remain in this location.

2.5.5.5.6 Risk to Listed sDPS Green Sturgeon

The fish monitoring data for both the prescreen period (1999-2011) and post screen installation period (2011-2018) report that no sDPS green sturgeon have ever been observed in sampling. This would indicate the risk for exposure and potential for entrainment and impingement to the water diversion operations is negligible. It is unlikely that juvenile sDPS green sturgeon would have the same predation risk as listed salmonids, and would see negligible increases in the rate of mortality due to remaining in this waterway for extended periods of time.

2.5.5.6 Water Transfers

2.5.5.6.1 Deconstruct the Action

Reclamation and DWR propose to transfer project and non-project water supplies through CVP and SWP south Delta export facilities. The effects of developing supplies for water transfers in any individual year or a multi-year transfer is evaluated outside of this proposed action. Water transfers would occur from July through November in volumes up to those described in Table 4-12 of the ROC on LTO BA [page 4-48; U.S. Bureau of Reclamation (2019)]. These volumes are the same as those proposed in 2008 by Reclamation for the NMFS 2009 BiOp consultation. The current transfer window extends from July 1 to September 30 of each year. Reclamation and DWR believe that extending the length of the transfer window will enhance the reliability of the water supply by providing greater flexibility to move water through the system when capacity is available at the export facilities. This may provide additional benefits in upstream actions such as improving Sacramento River temperature operations or providing for pulse flows in river reaches below dams when they would be beneficial to tailwater river reaches. Impacts from the proposed changes to the water transfer window include additional flows in Central Valley waterways and increased export levels over current operating conditions in October and November due to diverting transfer water when no additional pumping would have occurred without such transfers being made (i.e., the available capacity). Real-time operations may restrict transfers within the transfer window so that Reclamation and DWR can meet other authorized project purposes, e.g.,

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when pumping capacity is needed for CVP or SWP water. The proposed transfers require that NMFS make the following assumptions:

- Development of the water supplies for water transfers will be conducted in a manner that
 includes the necessary consultation process with NMFS for impacts to listed species as
 applicable;
- Any upstream impacts to listed species associated with operation of non-CVP/SWP facilities for transfer through the south Delta export facilities will be the subject of their own consultation process;
- This consultation covers the additional duration of the transfer window and the Shasta operations associated with transfers during dry conditions that are intended to support or improve Shasta temperature management. Effects were analyzed assuming a quantity and timing similar to the transfer implemented in 2014.
- This consultation also covers north-to-north transfers along the Sacramento River.
 Effects were analyzed assuming a quantity and timing of Keswick releases as would occur absent the transfer.

2.5.5.6.1.1 Sacramento River winter-run Chinook salmon

Neither adult nor juvenile winter-run Chinook salmon are likely to be present in the waters of the Delta during the majority of the proposed water transfer window (July 1 through November 30). There is a low potential for juvenile winter-run Chinook salmon to be present in the Delta during November if early season storms create flow conditions in the Sacramento River basin to stimulate downstream movements. Likewise, there is a low potential for adult winter-run Chinook salmon to be present in the Delta either at the very beginning of their upstream migration (November) or at the very tail end (late June) of their migration season. If transfer water originates at upstream locations such as Shasta Reservoir, then all life stages may be exposed to the release of waters from the reservoir for transfer through the river to the south Delta export facilities. This upstream exposure would be the subject of a separate consultation process (see assumptions).

In the upper Sacramento River reaches below Keswick Dam, adult winter-run Chinook salmon, incubating eggs, alevins, and emergent fry are likely to be present during the transfer window July 1 through November 30. Adult winter-run Chinook salmon spawn from late-April through mid-August with peak spawning in May and June. Fry emergence occurs from mid-June through mid-October. Once fry emerge, juveniles move to slow moving, channel margin habitats to rear. From July 1 through September 30, only spawning adults, incubating eggs and alevins in the gravel are present in the upper Sacramento River below Keswick Dam. During the period of the water transfer extension (October 1 through November 30), some incubating winter-run Chinook salmon eggs are still in the gravel from late spawning adults, and may remain in the gravel until November until they hatch. The majority of eggs should have hatched by the beginning to middle of October and alevins are either still in the gravel or have emerged as fry to rear in the nearshore areas of the Sacramento River. During October and November, older fry are moving downstream and are observed at the Red Bluff Diversion Dam (RBDD) rotary screw traps (RSTs).

2.5.5.6.1.2 CV Spring-Run Chinook Salmon

There is a slightly higher potential for CV spring-run Chinook salmon to be present in the Delta during the proposed water transfer window. Yearling CV spring-run Chinook salmon may be present in the Delta in October and November if upstream precipitation events in tributary watersheds stimulate downstream migration. Adult CV spring-run Chinook salmon may be present in the Delta during the tail end of their upstream migration in late June (and early July). If transfers originate from upstream reservoirs or other forms of water storage in the Sacramento River or San Joaquin River basin tributaries, there is the potential for all life stages to be exposed to the effects of water released for transfers during the July through November transfer window.

CV spring-run Chinook migration into the upper Sacramento River and tributaries extends from mid-March through the end of July with a peak in late May and early June. From July 1 to September 30, adult CV spring-run Chinook salmon are present. CV spring-run Chinook salmon spawning occurs during the first half of September and thus some eggs are present in the gravel during this earlier portion of the water transfer window. Eggs are laid in similarly cool-water reaches of the upper Sacramento as winter-run Chinook salmon. CV spring-run Chinook salmon fry will emerge in mid- to late November, when they are first observed at RBDD. During the period of the water transfer extension (October and November) the majority of spring-run will still be found as incubating eggs in the gravel in the river reaches below Keswick, although some fish have already hatched and emerged from the gravel during the later portion of tis transfer window extension.

2.5.5.6.1.3 CCV Steelhead

There is the potential for both adult and juvenile CCV steelhead life stages to be present in the Delta during the proposed water transfer window of July through November. Juvenile CCV steelhead may continue to out migrate through June and into July, based on monitoring data from the Sacramento trawl. Juveniles can also start to be seen again in early fall (October and November) as they migrate downstream into the Delta. This portion of their migration timing represents a small fraction of the population as most juveniles migrate into the Delta in winter. In contrast, most of the annual adult spawning migration into the Sacramento River basin occurs from August through November and would have a large overlap with the water transfer window. Adult CCV steelhead migrating into the San Joaquin River basin would be present in the Delta starting in September and overlap with at least the last 3 months of the transfer window (September through November). Juvenile CCV steelhead rear in the upper Sacramento below Keswick Dam, and in the tailwater sections below the terminal dams in Central Valley tributaries. These fish would be exposed to any water released for the purposes of water transfers. These upstream exposures would be the subject of their own consultation processes (see assumptions).

2.5.5.6.1.4 sDPS Green Sturgeon

Both juvenile and adult sDPS green sturgeon are expected to be present in the Delta during the entire year. Therefore, they would overlap with the entire proposed period of water transfers (July through November). Likewise, adult and juvenile sDPS green sturgeon would be present in the upper Sacramento and potentially the lower Feather River during the July through November period.

2.5.5.6.2 Assess Response of Species to the Proposed Water Transfer Window

For those fish present in the Delta during the water transfer window extension, there will be an increase in altered hydrodynamics in waters adjacent to the export facilities as a result of any additional exports to implement a water transfer. The risk of entrainment into the export facilities, coupled with alterations in routing probabilities within the waterways of the central and southern Delta will become more pronounced. The additional level of exports required to divert water for transfer are over and above that which would be normally present without the extended transfer window, as the transfer of water can only occur when there is available export capacity that is not needed for authorized SWP or CVP purposes at the facilities.

Additional risk of entrainment into the fish salvage facilities will increase the risk of mortality to exposed fish. Likewise, alterations in routing paths may increase the travel time or transit distance that a fish must travel to complete its migration behavior. Increases in either of these factors can lead to decreased survival rates through exposure to more predators for a greater distance or for more time (see DCC Operations Section 2.5.5.3.4 and references therein). These risks are more pronounced for juvenile fish than they are for adult fish.

In contrast to the negative effects of increased export levels upon fish in the vicinity of the CVP and SWP export facilities in the south Delta, changes in flows in the Sacramento and San Joaquin rivers will be generally beneficial to listed fish present during the water transfers. Water released for transfers will augment flows coming into the Delta, providing a shorter transit time in riverine sections of the river channels due to higher flows and velocities. This will decrease the exposure to predators by decreasing the time exposed to the ambient predator field. In addition, higher flows may increase the probability of staying in the "better route" for migration rather than diverting into channels that lead into the Delta interior with their associated lower survival rates. This can be accomplished by offsetting tidal influence in the transition areas between riverine and tidal habitat. Furthermore, additional flows are expected to enhance water quality in the lower reaches of the Sacramento and San Joaquin rivers prior to entering the Delta. Finally, increased flows due to water being released for transfers can provide better migratory cues for adult fish returning on their spawning migrations. These higher flows from tributary watersheds may reduce straying by providing stronger olfactory cues for returning salmonids to find their natal rivers.

In upper Sacramento River sections above the Delta, increased flows during the water transfer window will occur while winter-run and CV spring-run Chinook salmon eggs are still in the gravel incubating, and thus reduce the likelihood of redd dewatering. For those winter-run and CV spring-run Chinook salmon that have emerged from the gravel during the water transfer window, fry and juvenile salmonids will likely move to areas of the river that are inundated by the increased flows, utilizing the increased habitat area for rearing. The flow augmentation for the water transfers from Shasta Reservoir is likely to maintain flows between 3,250 and 6,000 cfs during the fall. Thus, the water transfer releases will not exceed flow thresholds (>12,000 cfs at Wilkins Slough) observed to trigger outmigration of winter-run Chinook salmon past Knights Landing (del Rosario et al. 2013). There is a risk to rearing and migrating fry of stranding in side channels and pools on the inundated streamside bench during ramp down of the reservoir releases. However adherence to the ramping rates required for Keswick Reservoir should minimize or avoid the risk of stranding. Adult CCV steelhead will be exposed to augmented flows which should improve their upstream migratory movements into the reaches below the dams, this is particularly true for the

American and Stanislaus rivers. The augmented flows should also increase the rearing area for juvenile CCV steelhead in these rivers, and will also likely improve water temperatures, provided that releases are conducted to maintain or improve water temperatures conditions in the river reaches downstream of the dams. A summary of the effects of the proposed water transfer window is provided in Table 2.5.5-64 in Section 2.5.5.14 Summary Tables of Stressors for each Project Component.

2.5.5.6.3 Risk to Listed Salmonids

For winter-run Chinook salmon and CV spring-run Chinook salmon, the overall risk of additional mortality associated with entrainment at the fish salvage facilities or routing into inferior migratory routes due to the water transfer window extension is low. This is primarily due to the lack of temporal overlap with the period of water transfers for most of their life history phases in the Delta (i.e., migrating adult and juvenile life stages)(Tables 2.5.5-17, 2.5.5-18, and 2.5.5-19). For those winter-run Chinook salmon and CV spring-run Chinook salmon that are present in the Delta during the water transfer window, they are expected to see some benefit from the increased in-river flows created by the release of water for transfer.

Adult CCV steelhead should experience positive effects of increased flows for attracting fish upstream on their migratory spawning runs. During the period from August through November when Sacramento River basin CCV steelhead are moving upstream into the Sacramento River basin, typical river flows are low. Increasing flows will provide stronger migratory cues and stronger olfactory signals to fish moving upriver. Juvenile CCV steelhead, if present, will have a greater risk of entrainment and re-routing into different migratory paths due to export actions. This has the potential to increase mortality within the Delta waterways.

In the upper river reaches, augmented flows during the water transfer window (July – November) will reduce the risk of redd dewatering for winter-run and CV spring-run Chinook salmon by maintaining flows in the river for a longer period. Augmented flows will also improve rearing habitat area size for winter-run and CV spring-run Chinook salmon fry as well as CCV steelhead juveniles, which ultimately may improve juvenile productivity. Flows are not expected to reach levels where downstream migration of winter-run Chinook salmon fry is stimulated after hatching. There is a risk to rearing and migrating fry of stranding in side channels and pools on the inundated streamside bench during ramp down of the reservoir releases. However adherence to the ramping rates required for Keswick Reservoir should minimize or avoid the risk of stranding.

2.5.5.6.4 Risk to Listed sDPS Green Sturgeon

As previously described in Section 2.5.5.1.4, adult, sub-adult, and juvenile sDPS green sturgeon are found within the waters of the Delta year-round. Juvenile sDPS green sturgeon have been observed in salvage at both the TFCF and the SDFPF during most months of the year (Figure 2.5.5-25 and Table 2.5.5-8) and would overlap with the proposed period of water transfers (July through November). Increased levels of exports to accommodate water transfers would elevate the risk of entraining juvenile sDPS green sturgeon present in the channels of Old and Middle rivers leading to the export facilities. It is unlikely that the levels of increased exports would increase the risk of entrainment of sub-adult or adult sDPS green sturgeon into the facilities due to the physical barrier created by the trash racks entering the primary louver bays, however, sturgeon may be temporarily detained in front of the trash racks due to the velocity of the water

flowing into the facility. At the TFCF, the trash rack is located directly adjacent to the Old River channel, and fish can escape to other parts of the river channel when necessary by swimming against the current. At the SWP, the CCF is a ~2,500 acre waterbody that functions as a regulating forebay, and sturgeon are first entrained into this waterbody when the radial gates are opened to the Old River channel prior to encountering the trash racks at the SDFPF. Adult, subadult, and juvenile fish may have long resident times in this forebay after being entrained into CCF. Inflow velocities at the radial gates are typically quite strong depending on the difference in water surface elevation between Old River and the CCF, and egress from the forebay is difficult until the flow velocity diminishes as water surface elevations become similar between the two sides of the gate. Any sDPS green sturgeon within CCF would need to swim through the radial gate structure to escape CCF and reenter the Delta via Old River when inflow velocities are sufficiently low to permit their upcurrent movement, and before the gates are closed at the end of the tidal cycle.

In other parts of the Delta, adult, sub-adult, and juvenile sDPS green sturgeon may benefit from the increased flow of water into the Delta from upstream releases for water transfers. Higher flows will help transport adults downstream after spawning in the upstream Sacramento River reaches. Likewise, juvenile sDPS green sturgeon migrating downstream will benefit from the enhanced flows. Water quality conditions in the lower river reaches should improve with the additional flow, increasing circulation in these areas and also improving water quality conditions within the Delta.

In the upper river sections of the Sacramento River, the augmented flows are not anticipated to create conditions that stimulate downstream movements of adult and sub adult sDPS green sturgeon beyond the baseline flows without transfers. Migratory behavior in adult and sub adult sDPS green sturgeon is typically stimulated by fall and early winter precipitation events that substantially increase the river flows and decrease ambient water temperatures. It is unlikely that the release of transfer water will be of sufficient volume to increase flows and reduce water temperatures to the degree necessary to stimulate migratory behavior. Furthermore, early movement of adult or sub adult sDPS green sturgeon downstream into the Delta due to augmented flows from water transfers is not anticipated to cause any negative effects to these fish. Juvenile sturgeon typically hold in upriver locations during their first year before migrating downstream into the Delta. These fish hold in upriver locations during flows of much higher magnitude than would be anticipated from the water transfer releases. Thus, there is no anticipated negative impacts from the water transfer releases during the extension period.

2.5.5.7 Suisun Marsh

2.5.5.7.1 Suisun Marsh Salinity Control Gates Operation

2.5.5.7.1.1 Physical Description of the Suisun Marsh Salinity Control Gates Operation

The Suisun Marsh Salinity Control Gates (SMSCG) are located on Montezuma Slough about 2 miles downstream of the confluence of the Sacramento and San Joaquin rivers, near Collinsville, California. The SMSCG span the 465-foot width of Montezuma Slough. The facility consists of three radial gates, a boat lock structure, and a maintenance channel that is equipped with removable flashboards. When the SMSCG are in operation, the flashboards are installed at the maintenance channel and the gates are operated tidally.

To evaluate the potential effects of the SMSCG operations on adult salmonid passage, telemetry studies were conducted on adult Chinook salmon starting in 1993. In seven different years (1993, 1994, 1998, 2001, 2002, 2003, and 2004), migrating adult fall-run Chinook salmon were tagged and tracked by telemetry in the vicinity of the SMSCG. These studies showed that the operation of the SMSCG delays passage of some adult Chinook salmon, while other adult Chinook salmon never pass through the SMSCG and instead swim downstream for approximately 30 miles to Suisun Bay and then access their natal Central Valley streams via Honker Bay. Based on the results of studies, the CDFG (now CDFW) recommended modifications to the structure to improve passage (Edwards et al. 1996, Tillman et al. 1996). In 1998, modifications were made to the flashboards at the SMSCG maintenance channel to include two horizontal openings, but telemetry monitoring indicated that the modified flashboards did not improve Chinook salmon passage (Vincik et al. 2003). Telemetry studies conducted in 2001, 2002, 2003, and 2004, evaluated the use of the existing boat lock as a fish passageway. These results indicated that fish passage improved when the boat lock was opened. Successful passage rates improved by 9, 16, and 20 percent in 2001, 2003, and 2004, respectively, when compared to full SMSCG operation with the boat lock closed. In addition, opening of the boat lock reduced mean passage time by 19 hours, 3 hours, and 33 hours in 2001, 2003, and 2004, respectively. The 2002 results did not confirm these findings, but equipment problems at the structure during the 2002 season likely confounded the 2002 fish passage studies (Vincik et al. 2003).

The purpose of gate operation is to decrease the salinity of the water in Montezuma Slough to meet salinity standards set by the SWRCB and Suisun Marsh Preservation Agreement. The SMSCG control salinity by lowering gates during flood tides to prevent flow of higher salinity water from Grizzly Bay into Montezuma Slough and opening gates during ebb tides to retain the lower salinity Sacramento River water that entered the marsh during the previous ebb (outgoing) tide. Currently, SMSCG operation occurs from October to May (~10-20 days) where radial gates are lowered during the flood tides and opened during the ebb tides, flashboards are in place through September, and a boat lock is operated as-needed for passing vessels. The boat lock portion of the gate is held open at all times during SMSCG operation to allow for continuous Chinook salmon passage opportunity. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility. Outside of the period, the radial gates remain open, flashboards are removed, and operation of the boat lock is not needed. As of 2018, gates are operated during August in "below normal" or "above normal" water years in addition to October to May operation.

2.5.5.7.1.2 Deconstruct the Action - Proposed Suisun Marsh Salinity Control Gates Operation

In addition to the October through May operation to meet Suisun Marsh water quality standards, Reclamation proposes operating the SMSCG on the tidal cycle in below-normal and above-normal years in June through September for 60 days, not necessarily consecutive, to improve Delta Smelt critical habitat. Under the PA (February 5, 2019; Appendix A1) component, Reclamation and DWR would increase tidal operations of the SMSCG to direct more fresh water in Suisun Marsh to reduce salinity, increase food, and improve habitat conditions for Delta smelt. This would be combined with Roaring River Distribution System management for food production and flushing freshwater through the Roaring River Distribution System to increase

the low salinity habitat in Grizzly and Honker bays. Reclamation and DWR will continue to meet existing D-1641 salinity requirements in the Delta and Suisun Marsh.

2.5.5.7.1.3 Assess Species Exposure to Proposed Suisun Marsh Salinity Control Gates Operation

The boat lock portion of SMSCG is held open at all times during SMSCG operation to allow for continuous salmonid passage opportunities. With increased understanding of the effectiveness of the gates at lowering salinity levels in Montezuma Slough, salinity standards have been met with less frequent gate operation compared to the early years of operations. The PA component would continue SMSCG operation for up to 20 days in October to May, plus an additional 60 days during June to September in above normal and below normal years. During the summer and early fall months, listed fish species are less likely to be present. However, adult and juvenile CCV steelhead and sDPS green sturgeon are known to be present in the Delta during some or all of these months. A summary of the effects of the proposed SMSCG operation is provided in Table 2.5.5-65 in Section 2.5.5.14 Summary Tables of Stressors for each Project Component.

2.5.5.7.1.4 Risk to Salmonids

The principal potential effect of the SMSCG being closed for up to 20 days per year from October through May, plus an additional 60 days per year from June to September, is delay of upstream-migrating adult winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead that have entered Montezuma Slough from its westward end, and are seeking to exit the slough at its eastward end. del Rosario et al. (2013) found some evidence that opening of the boat lock improved passage rates of acoustically tagged adult Chinook salmon, and that even with the gates opened, ~30-40 percent of fish returned downstream. Adult salmonids that do not continue upstream past the SMSCG are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker bays(California Department of Water Resources and California Department of Fish and Game 2005).

During the majority of the period from October to May, the SMSCG will not be operated and no fish passage delays due to the gates are anticipated. However, during the annual 10-20 days of periodic operation, individual adult salmonids and sDPS green sturgeon may be delayed in their spawning migration from a few hours to several days. The effect of this delay is not well understood. Winter-run Chinook salmon are typically several weeks or months away from spawning and, thus, they may be less affected by a migration delay in the estuary. CCV steelhead migrate upstream as their gonads are sexually maturing and a delay in migration may negatively impact their reproductive viability. CV spring-run Chinook salmon are typically migrating through the estuary several months before spawning, but an extended delay in the estuary may affect their ability to access their natal spawning streams. CV spring-run Chinook salmon generally utilize high stream flow conditions during the spring snowmelt to assist their upstream migration. Rapid upstream movement may be needed to take advantage of a short duration high stream flow event, particular in dry years when high flow events may be uncommon. If the destination of a pre-spawning adult salmon or CCV steelhead is among the smaller tributaries of the Central Valley, it may be important for migration to be unimpeded, since access to a spawning area could diminish with receding flows.

Under the PA relative to current operations, operation of the SMSCG would increase by 60 days per year during the months of June to September in above normal and below normal years. This additional gate operation during the summer and early fall months is expected to have a minimal impact on adult and juvenile CCV steelhead that may be present during that time. However, the boat lock portion of SMSCG is held open at all times during SMSCG operation to allow for continuous salmonid passage opportunities. Therefore, the potential for negative near-field effects on downstream-migrating juvenile salmonids would be limited. Adult salmonids are at risk of delay if encountering closed SMSCG while the boat lock is closed for vessel passage, but salmonids could backtrack around the structure. The proportion of individuals that would do so is uncertain, and as described above, CV spring-run Chinook salmon and CCV steelhead would likely experience greater negative effects than winter-run Chinook salmon, because CV spring-run Chinook salmon and CCV steelhead are more reliant on short-term high flow events in smaller tributaries to provide access to suitable spawning habitat.

Salmonid smolt predation by striped bass and pikeminnow could be exacerbated by operation of the SMSCG. These predatory fish are known to congregate in areas where prey species can be easily ambushed. Pikeminnow are not typically major predators of juvenile salmonids (Brown and Moyle 1981), but both pikeminnow and striped bass are opportunistic predators that will take advantage of localized, unnatural circumstances. The SMSCG provides an enhanced opportunity for predation because fish passage is blocked or restricted when the structure is operating. However, DWR proposes to limit the operation of the SMSCG to only periods required for compliance with salinity control standards, and this operational frequency is expected to be 10-20 days per year. Therefore, the SMSCG will not provide the stable environment which favors the establishment of a local predatory fish population and the facility is not expected to support conditions for an unusually large population of striped bass and pikeminnow. In addition, most listed Central Valley salmonid smolts reach the Delta as yearlings or older fish. Since the size and type of prey taken by pikeminnow varies with the size and age of the fish (Brown and Moyle 1981), the relatively large body size and strong swimming ability of listed salmon and steelhead smolts reduce the likelihood of being preyed upon.

2.5.5.7.1.5 Risk to sDPS Green Sturgeon

Little is known about adult sDPS green sturgeon upstream passage at the SMSCG, with existing studies suggesting that Suisun and Honker bays are more utilized than Montezuma Slough where the SMSCG are located. NMFS anticipates that adult sDPS green sturgeon would have the opportunity to pass the SMSCG through the boat lock or gates (when open), as adult salmonids do, but that they could be delayed. sDPS green sturgeon spawn in the deep turbulent sections of the upper reaches of the Sacramento River, and spring stream flows in the mainstem Sacramento River are generally not limiting their upstream migration. It is also common for sDPS green sturgeon to linger for several days in the Delta prior to initiating their active directed migration to the upper Sacramento River. Thus, any delays would not affect access to spawning habitat in the upper Sacramento River because adult sDPS green sturgeon tend to spawn in deeper water (Poytress et al. 2015) that would not be affected by temporary changes in flow. In addition, previous concerns regarding potentially delaying arrival at RBDD (where passage was previously restricted) no longer apply, because the RBDD gates are up year-round, allowing unimpeded passage. The potential for predation near the SMSCG that was previously discussed for juvenile salmonids would be of minimal concern for juvenile sDPS green sturgeon because

they are relatively large and unlikely prey for striped bass and Sacramento pikeminnow. In addition, the multi-year estuarine residence of juvenile sDPS green sturgeon often includes long periods of localized, non-directional movement interspersed with occasional long-distance movements (Kelly et al. 2007), and such movements are unlikely to be negatively affected by periodic delays ranging from a few hours to a few days at the SMSCG.

2.5.5.8 South Delta Export Operations

In the analysis of this PA (February 5, 2019; Appendix A1) component, NMFS considers two primary categories of effects in the south Delta due to water export: (1) entrainment and loss at the south Delta export facilities, and (2) water-project-related changes to south Delta hydrodynamics that may reduce the suitability of the south Delta for supporting successful rearing or migration of salmonids and sturgeon from increased predation probability and exposure to poor water quality conditions. The effects from the PA components with regard to entrainment and loss at the south Delta export facilities are described in Section 2.5.5.8.3.1 South Delta Salvage and Entrainment. The effects related to water-project-related changes to south Delta hydrodynamics that may reduce the suitability of the south Delta for supporting successful rearing or migration of salmonids and sturgeon, include the impacts to listed fish travel time, outmigration, behavior changes, and juvenile survival from south Delta hydrodynamics.

Water is diverted at two main facilities in the South Delta for export to regions south of the Delta and to the areas immediately adjacent to the Delta, including portions of the Bay area. The CVP operates the Jones Pumping Plant, the Delta Mendota Canal, and the TFCF. The SWP operates CCF, the SDFPF and the Harvey O. Banks Pumping Plant.

Key water-project-related drivers of south Delta hydrodynamics are Vernalis inflow, CVP and SWP exports from the south Delta export facilities, and the presence or absence of the Head of Old River (HOR) Barrier; these drivers interact with tidal influences over much of the central and southern Delta. In day-to-day operations, these drivers are often correlated with one another (for example, exports tend to be higher at higher San Joaquin River inflows) and regulatory constraints on multiple drivers may simultaneously be in effect. The modeling of the PA and COS conditions reflects those realities and, while those scenarios are appropriate for project analysis, they have limited value for evaluating the isolated effects of one driver vs. another. Recently, the Salmonid Scoping Team, a technical team associated with the Collaborative Adaptive Management Team (CAMT) process, evaluated how the relative influence of these drivers on hydrodynamic conditions varied temporally and spatially throughout the south Delta, [(Salmonid Scoping Team 2017a): Appendix B: Effects of Water Project Operations on Delta Hydrodynamics]. In order to describe the driver-specific effects on south Delta hydrodynamics which are relevant to the types of operations anticipated in the PA, highlights of that report are provided below. While the specific combinations of drivers in the Salmonid Scoping Team (2017a) analysis are not necessarily representative of any specific PA scenario, these scenarios cross factor individual drivers in a way that allows the evaluation of trends that are relevant to the PA. Key findings, with examples of relevance to effects of south Delta operations under the PA, include:

 The major river channel distributaries in the south Delta (San Joaquin, Old, and Middle rivers) transition from a riverine environment to a tidally-dominated environment in the Delta. The effect of tides decreases with increasing distance upstream on the main stem river channels, and the tidally dominated region varies with Delta inflow, exports, and tidal phase.

• The hydrodynamic effect of increases in Delta inflow on flow and velocity in the south Delta is greatest at the upstream reaches of the major river channels; diminishes with distance downstream through the Delta or away from the main stem rivers (i.e., into the interior Delta); and is affected by barriers, tidal phase, and exports.

The hydrodynamic effect of exports on flow and velocity in the south Delta is strongest in Old River near the export facilities, in Middle River at Victoria Canal, and the downstream ends of Turner Cut, and Columbia Cut; and it is affected by tidal phase, Delta inflow, distance from the exports, and barriers. South Delta exports in the PA are expected to have the stronger effects in DSM2 channels 89 (Old River downstream of the south Delta export facilities) and DSM2 channel 143 (Middle River near Woodward Island) compared to locations on the main stem San Joaquin River (DSM2 channels 45 and 49), as shown in the velocity density overlap plots (Figure 2.5.5-29, Figure 2.5.5-30, and Figure 2.5.5-31).

The Delta flow regime can have effects on a wide range of factors, such as productivity, food webs, or invasive species, and management actions related to CVP and SWP operations, which are just a few of many interacting drivers (Monismith et al. 2014, Delta Independent Science Board 2015)

(Figure 2.5.5-32). The effects of south Delta export operations on listed winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are described below. Export effects in the south Delta are expected to reduce the probability that juvenile salmonids in the south Delta will successfully migrate out past Chipps Island, either via entrainment or mortality in the export facilities, or via changes to migration rates or routes that increase residence time of juvenile salmonids in the south Delta and thus increase exposure time to agents of mortality such as predators, contaminants, and impaired water quality parameters (such as dissolved oxygen or water temperature). Export effects of ongoing diversions from the south Delta export facilities negatively impact hydrodynamic conditions in the south Delta, and impacts are modelled to increase in the PA compared to the COS as exports are increased, particularly in April and May, and less reductions in exports for fishery protections are anticipated under the PA.

Much uncertainty remains about how reach-scale hydrodynamic effects link to salmonid migration behavior in the south Delta. More data are available on both through-Delta survival and reach-scale survival for Chinook salmon and CCV steelhead. Salmonid Scoping Team (2017a, 2017b) summarize select data relevant to water-project-related effects on juvenile salmonid migration and survival in the south Delta [see in particular Appendices D and E of Volume 1 (Salmonid Scoping Team 2017a)]. While those reports did not evaluate specific elements of the PA, they were designed to summarize the latest information on salmonid behavior and survival in the south Delta in the context of water project operations and so offer relevant information to understanding effects of south Delta operations in the PA. Some overarching findings, summarized in the Executive Summary from Volume 1 (Salmonid Scoping Team 2017a), are:

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- "Spatial variability in the relative influence of Delta inflow and exports on hydrodynamic conditions means that any given set of operational conditions may differentially affect fish routing and survival in different Delta regions."
- "Gates and barriers influence fish routing away from specific migration corridors."
- "The relationship between San Joaquin River inflow and survival is variable, and depends on barrier status and region of the Delta."
- "Juvenile salmonid migration rates tend to be higher in the riverine reaches and lower in the tidal reaches."
- "The extent to which management actions such as reduced negative OMR reverse flows, ratio of San Joaquin River inflow to exports, and ratio of exports to Delta inflow affect through-Delta survival is uncertain."
- "Uncertainty in the relationships between south Delta hydrodynamics and through-Delta survival may be caused by the concurrent and confounding influence of correlated variables, overall low survival, and low power to detect differences."

The first four findings highlight that effects on routing and survival differ across the Delta and are sensitive to inflow and barrier status. The final two findings relate to uncertainties and highlight the need for continued evaluation and testing of hypotheses linking project-related effects on hydrodynamics to biological responses, ideally in a formal adaptive management program.

2.5.5.8.1 Facility Descriptions

2.5.5.8.1.1 Tracy Fish Collection Facility

The TFCF is located in the southwest portion of the Sacramento-San Joaquin Delta near the Cities of Tracy and Byron. It uses behavioral barriers consisting of primary and secondary louvers to guide entrained fish into holding tanks before transport by truck to release sites within the Delta. The original design of the TFCF focused on smaller fish (<200 mm) that would have difficulty fighting the strong pumping plant-induced flows, since the intake is essentially open to the Delta and also impacted by tidal action.

The primary louvers are located in the primary channel just downstream of the trash rack structure. The secondary travelling screens (hydrolox screens) are located in the secondary channel just downstream of the primary bypasses. The primary louvers allow water to pass through into the main Delta-Mendota intake channel and continue towards the Bill Jones Pumping Plant located several miles downstream. However, the openings between the louver slats are tight enough and angled against the flow of water in such a way as to prevent most fish from passing between them and, instead, guide them into one of four bypass entrances positioned along the louver arrays. The efficiency of the louver guidance array is dependent on the ratio of the water velocity flowing into the bypass mouth and the average velocity in the main channel sweeping along the face of the louver panels.

When south Delta hydraulic conditions allow, and within the original design criteria for the TFCF, the louvers are operated with the D-1485 objectives of achieving water approach velocities for striped bass of approximately 1 foot per second (fps) from May 15 through October 31, and for salmon of approximately 3 fps from November 1 through May 14. Channel velocity criteria are a function of bypass ratios through the facility. Louver efficiency at the TFCF is

dependent on the flow and velocities, fish species, and the fish size (life stage). The number of pumps (units) running at the Jones Pumping Plant (JPP) dictates the flow and velocity at the TFCF. There are 6 units at JPP but a maximum of 5 can used; each unit increases the velocity through the TFCF primary channel about 0.5 ft/sec. For juvenile Chinook salmon, the most recent whole facility efficiency evaluations completed using acoustic tag telemetry suggests that primary louver efficiency ranges from 50-100 percent with an average of approximately 88.7 percent (Karp et al. 2017, Wu and Fullard 2018). At higher pumping regimes of 4-5 JPP units, for juvenile Chinook salmon, louver efficiency was high at 71.4-100 percent (Karp et al. 2017).

Sutphin and Bridges (2008) has indicated that under the low pumping regimen required by the Vernalis Adaptive Management Plan (VAMP) experiment, primary louver efficiencies (termed capture efficiencies in the report since only one bypass was tested) can drop to less than 35 percent at the TFCF. The reductions in pumping create low velocities in the primary channel, and the necessary primary bypass ratios (>1) cannot be maintained simultaneously with the secondary channel velocities (3.0 to 3.5 fps February 1 through May 31) required under D-1485. These study results indicate that loss of fish can potentially increase throughout the entire louver system if the entire system behaves in a similar way as the test section performed in the experiments.

Screening efficiency for juvenile green sturgeon is unknown, although apparently somewhat effective given that green sturgeon, as well as white sturgeon, have been collected during fish salvage operations. Studies by Kynard and Horgan (2001) tested the efficiency of louvers at guiding yearling shortnose sturgeon (*Acipenser brevirostrum*) and pallid sturgeon (*Scaphirhynchus albus*) under laboratory conditions. They found that louvers were 96 to 100 percent efficient at guiding these sturgeon species past the experimental array and to the flume bypass. However, both sturgeon species made frequent contacts with the louver array with their bodies while transiting the louver array. The authors also found that sturgeon would rest at the junction between the louver array and the tank bottom for extended periods. This behavior may degrade the effectiveness of the louver array to guide fish towards the bypass. Current studies at the University of California at Davis are testing louver screening efficiencies for sturgeon using sections of louver panels from the south Delta facilities.

"Pre-screen loss rate" is defined as "the rate of loss to entrained salmon during movement from the trash racks to the primary louvers" (Aasen 2013). In essence, the "pre-screen loss rate" is the predation rate within the primary channel. Although Chinook salmon mortality have been observed in front of the TFCF trash rack (Vogel 2010), this mortality is not included in the pre-screen loss calculation since this is outside of the area between the trash rack and primary louvers. Currently, a 15 percent pre-screen loss rate due to predation is an agreed upon placeholder value but has yet to be fully verified. For this placeholder, the predation rate within the primary channel is currently being verified with the use of Predation Detection Acoustic Tags (PDAT).

Prescreen loss at the TFCF is dependent on fish species, fish size (life-stage), and predator load within the primary channel. In addition, it appears that prescreen loss may be inversely correlated with pumping rates (water velocity) and/or turbidity, although more data need to be collected to adequately determine these relationships. Data from Karp et al. (2017) and Wu and Fullard (2018) suggest that prescreen loss ranges from 0- 40 percent for juvenile Chinook salmon. Low estimates of pre-screen loss (assuming all unknown fates in the primary channel are non-

participants) from these studies average approximately 14.0 percent, while high estimates of prescreen loss (assuming all unknown fates in the primary channel are losses to predation) average approximately 15.9 percent. Therefore, preliminary results indicate that the predation rate (or prescreen loss) may be close to the 15 percent placeholder value mentioned above (Karp et al. 2017, Wu and Fullard 2018).

Loss due to cleaning is not quantified in the current loss calculation, and therefore, the reported loss is chronically underestimated. Reclamation estimates that approximately 6.7 percent of juvenile Chinook salmon that encounter the louvers are lost through the louvers when they are lifted for cleaning, and approximately 33.3 percent of louver loss occurs during louver cleaning activity (Karp et al. 2017). This value, however, is preliminary and needs further verification. There is a Tracy Fish Facility Improvement Plan (TFFIP) study plan being developed to study the amount of loss occurring during louver cleaning.

The current primary louver cleaning procedures and operations involve lifting each individual louver panel, 36 total, out of the water in order to spray wash the debris. Generally, each primary louver panel is lifted and lowered back into place three times per day (generally at 600-0800, 1400-1600, and 2300-0100 hours), although frequency of cleaning may be increased or decreased according to pumping rate and debris loads. It takes approximately 3-7 minutes to lift, spray clean, and lower each louver panel back into place. While export pumping may be reduced to address damaged louver panels, issues during cleaning, or other maintenance scenarios where facilities are not capable of effectively salvaging fish, complete shutdown of pumping usually does not occur due to issues related to the primary louvers. At a minimum, all 36 louver panels are cleaned 2-3 times a day but during heavy debris loads, operators clean 3-6 times a day. The 2018 louver cleaning data (see below) suggests less frequent cleaning is required in early summer (low averages of 60 minutes per day) and much higher during the winter months (high averages of 440 minutes per day). This means that there is a gap in the louver panels ranging from 1 to 7.5 hours per day depending on season, pumping rates, and debris loads.

Data from	Cleaning	Primary	Louvers	(2018))
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Month	Average daily (minutes)	
January	240	
February	131	
March	112	
April	64	
May	76	
June	138	
July	274	
August	310	
September	200	
October	440	

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Secondary bypasses are not cleaned, although they are shut during the cleaning of the primary louvers to prevent excessive debris from entering the holding tanks.

Fish salvage occurs at the TFCF 24 hours per day, 365 days per year. Fish are salvaged in flow-through holding tanks (6.1-m diameter, 4.7-m deep) that provide continuous flows of water (Sutphin and Wu 2008). Fish are maintained in these holding tanks for 8-24 hours depending on the species of fish that are being salvaged, the number of fish salvaged, and debris load. The number of fish that are salvaged in TFCF holding tanks is generally estimated by performing a 30-minute fish-count subsample every 120 minutes. The number of each species of fish collected in the subsample is determined and then multiplied by 4 (120 pumping minutes/30-minute fish-count subsample = expansion factor of 4) to estimate the total number of each species of fish, as well as the total number of fish, that were salvaged in TFCF holding tanks during the 120-minute period. Pumping minutes and fish-count minutes could potentially deviate from 120 minutes and 30 minutes, respectively, which would change the expansion factor used to estimate total fish salvage. This is typically done when the numbers of fish salvaged are high or there is heavy debris loading in the holding tanks.

If no Chinook salmon, steelhead, or Delta smelt are salvaged, other species of fish can be maintained in TFCF holding tank for up to 24 hours. If a Chinook salmon or steelhead is collected during fish-counts, fish can only be maintained in TFCF holding tanks for up to 12 hours. If a Delta smelt is collected during fish count, salvaged fish may only be held in TFCF holding tanks for up to 8 hours. When fish can be maintained in TFCF holding tanks for 24 hours, fish transport (fish-haul) generally occurs at approximately 0700 each day. When 2 fish hauls per day are necessary, fish hauls generally occur at 0700 and 2130 each day. When 3 fish hauls are necessary, they are usually completed at 0700, 1500, and 2130 each day. The frequency of fish hauls is also dictated by the Bates Tables which uses size classes, species, and water temperature as indicators for when to conduct a fish haul.

During normal operations, salvaged fish are transported approximately 49.9 km and released at one of two Reclamation release sites near the confluence of the Sacramento and San Joaquin rivers (Antioch Fish Release Site and Emmaton Fish Release Site). In general, the Emmaton Fish Release Site is used for fish hauls performed during daytime hours and the Antioch Fish Release Site is used for fish hauls performed during nighttime hours. This is done for safety and security reasons as the Antioch Fish Release Site has a gate that can be locked behind the operator after he/she enters the release site area. Upon arrival at release sites, operators measure certain important water quality parameters (dissolved oxygen, salinity, and temperature) prior to releasing fish. This is done to verify that water quality parameters remain acceptable during fish transport. Salmon loss due to handling and trucking are generally low and are based on CDFW trucking and handling studies. Salmon loss is < 2 percent for salmon < 100 mm and zero percent for salmon > 100 mm (Aasen 2013).

Estimates of post-release survival and mortality are currently not available, although release site survival and mortality is being investigated by Reclamation (Fullard et al. 2018) and results are anticipated within the next couple of years. It is anticipated that loss to predation is the main source of post release mortality.

2.5.5.8.1.2 Skinner Delta Fish Protection Facility

The John E. Skinner Fish Protection Facility was built in the 1960s and designed to prevent fish from being entrained into the water flowing to the Harvey O. Banks Pumping Facility, which lifts water from the inlet canal into the California Aqueduct. The fish screening facility was designed to screen a maximum flow of 10,300 cfs. Water from the Delta is first diverted into CCF, a large artificially flooded embayment that serves as a storage reservoir for the pumps, prior to flowing through the louver screens at the SDFPF. After water enters CCF through the radial gates, it first passes a floating debris boom before reaching the trashrack. The floating debris boom directs large floating material to the conveyor belt that removes the floating material for disposal in an upland area. Water and fish flow under the floating boom and through a trashrack (vertical steel grates with 2-inch spacing) before entering the primary screening bays. There are 7 bays, each equipped with a flow control gate so that the volume of water flowing through the screens can be adjusted to meet hydrodynamic criteria for screening. Each bay is shaped in a "V" with louver panels aligned along both sides of the bay. The louvers are comprised of steel slats that are aligned 90 degrees to the flow of water entering the bay with 1inch spacing between the slats. The turbulence created by the slats and water flowing through the slats guides fish to the apex of the "V" where bypass orifices are located. Fish entrained into the bypass orifice are carried through underground pipes to a secondary screening array. The older array uses the vertical louver design while the newer array uses a perforated flat plate design. Screened fish are then passed through another set of pipes to the holding tanks. Fish may be held in the holding tanks for up to 8 hours, depending on the density of salvaged fish and the presence of listed species.

Like the TFCF, the louvers are not 100 percent efficient at screening fish from the water flowing past them. Louver efficiency is assumed to be approximately 75 percent [74 percent, (California Department of Water Resources 2005)] for calculating the loss through the system. Louver efficiency estimates for Chinook salmon developed in the past 10 years are largely consistent with the findings of the original testing program for the SDFPF (Skinner 1974)]. More recent studies have examined louver efficiencies at the SDFPF. Clark et al. (2009) found louver efficiencies for steelhead using releases of PIT-tagged hatchery steelhead released at the SDFPF trash rack. The study reported two estimates of efficiency; 74 percent (range 17 to 100 percent) and 82 percent (range 19 to 100 percent). The latter value incorporates an estimate of emigration from the study area (e.g., "swim out") which was documented in the study. Wunderlich (2015) used fall-run Chinook salmon tagged with PIT tags which were released in front of the SDFPF in April and May of 2013. Louver efficiency was reported as 74 percent (ranging 71 to 76 percent). Miranda (2019) utilized releases of PIT and acoustic tagged fall and late-fall run Chinook salmon released at the SDFPF trash rack. Efficiency was reported as 81.7 percent (range 77.9 to 86.2 percent) and 55.0 percent (range 54.3 and 55.7 percent) for "Salmon" and "Striped Bass" Operating Criteria, respectively.

"Pre-screen loss" is the estimated loss of fish from the radial gates at the entrance to the CCF to the trash rack in front of the primary louver bays at the SDFPF. The pre-screen loss estimates for Chinook salmon developed in the past 10 years are largely consistent with the historical studies outlined in Gingras (1997), which ranged from 63-99 percent. Clark et al. (2009) calculated pre-screen loss rates from paired releases of PIT and acoustic tagged fish released at the CCF radial gates and at the SDFPF trash rack. Pre-screen loss was calculated as 82±3 percent and 78±4 percent (when adjusted for emigration of tagged fish from CCF). Wunderlich (2015) utilized

releases of PIT tagged, fall-run Chinook salmon released at the radial gates and the SDFPF in April and May of 2013. A pre-screen loss rate of 81.14 percent was reported, ranging from 41 to 100 percent. Miranda (2016) utilized PIT tagged late-fall and fall-run Chinook salmon released at the CCF radial gates from January through May of 2016. Monthly estimates of mean pre-screen loss ranged from 75 to 91 percent, with a season mean estimate of 91 percent. Miranda (2019) utilized releases of PIT and acoustic tagged fall and late-fall run Chinook salmon released at the CCF radial gates and at the head of the SDFPF. Pre-screen loss was estimated as 77.16 percent for all races combined. Pre-screen loss was estimated as 56.07 percent (26.1 to 88.5 percent) for late-fall run Chinook salmon, and 92.1 percent (92.1 to 98.5 percent) for fall-run Chinook salmon.

Losses due to cleaning the primary louvers at the SDFPF are quite low compared to the TFCF. The SDFPF was built with a modular design including multiple primary louver bays that can be isolated, two secondary channels, and two holding tank buildings. Under most circumstances, this design effectively mitigates fish losses as a result of routine maintenance and cleaning, and mechanical breakdowns. Maintenance, cleaning, and breakdowns normally result in a reduction in overall available capacity rather than exports without salvage. However, in the event of an unplanned outage (e.g., a power loss), attempts are made to immediately rectify the issue through either changes in the configuration of the facility (e.g., changing bays) or backup systems (e.g., alternate power source) and CDFW is notified. In the event of an unplanned outage lasting greater than 1 hour, CDFW is immediately consulted and/or Banks pumping plant exports may be temporarily halted. Planned outages are typically scheduled to avoid periods of unscreened water export. For example, major maintenance activities are scheduled in the spring during a 1 week complete shutdown of Banks Pumping Plant coinciding with NMFS 2009 Opinion RPA Action IV.2.1 (previously VAMP). During other periods, export capacity of the facility is reduced accordingly.

The duration and frequency of louver cleaning operations fluctuates significantly due to a number of factors including pumping schedule, high fish counts, flow rates, debris loads, environmental factors, and staffing. In general:

- Cleaning of individual primary louver bays is performed weekly. It takes a minimum of 2
 hours to clean each bay, and bays are isolated during cleaning to prevent fish losses.
 Cleaning is performed by lifting individual louver panels using a gantry crane and
 pressure washing them from both front and back.
- Cleaning of the secondary channels is performed twice weekly and is also used as a
 predator flush. It generally takes 30-60 minutes to clean each secondary bay. During
 cleaning, each channel is dewatered and the louver or screen panels are pressure washed
 from each side using a fire hose. After the panels have been washed, the primary bypass
 valve(s) at the head each bay are opened rapidly to flush predators and debris into a
 holding tank for removal.

Salvage of fish occurs at the SDFPF up to 24 hours per day, 365 days per year. Fish are salvaged in flow-through holding tanks that provide continuous flows of water. The number of fish that are salvaged in SDFPF holding tanks is generally estimated by performing a 30 minute fish-count subsample every 120 minutes. However, this may change due to the number of fish salvaged or the level of debris in the holding tank. The fraction of time sampled is used to

calculate the salvage expansion factor, as was done at the TFCF. Fish are transported to release sites on the San Joaquin River near Antioch, and on the Sacramento River near Horseshoe Bend.

The effects of Collection, Handling, Trucking, and release operations have been evaluated in a number of studies at the SDFPF, as outlined below. No attempt has been made to quantify post-release survival due to logistical challenges and because it likely fluctuates wildly based on a number of factors including, but not limited to, the number of fish being released, season, and frequency of release. Raquel (1989) found that survival rates for Chinook salmon were never less than 98 percent and, in most cases, was 100 percent. The loss equation used by CDFW to calculate SWP losses utilizes the 2 percent value. This study also found no detrimental effects to steelhead from the handling and trucking process. Miranda and Padilla (2010) found that the survival of Chinook salmon exposed to a mock salvage release process was 99.2 percent, 97.4 percent, and 98.4 percent in trials with no debris, moderate debris, and heavy debris, respectively. There was no significantly detectable effect on survival from the release process.

2.5.5.8.2 OMR Flow Management

Note that supplemental analysis based on PA revisions received June 14, 2019 is provided in Section 2.5.5.11.

Reclamation and DWR propose to operate the CVP and SWP in a manner that maximizes exports while minimizing entrainment of fish and protecting critical habitat. Net OMR flow provides a surrogate indicator for how export pumping at Banks and Jones Pumping Plants influence hydrodynamics in the south Delta. Reclamation proposes to manage OMR, in combination with other environmental variables, to minimize the entrainment of fish in the south Delta and at CVP and SWP fish salvage facilities. Reclamation and DWR propose to maximize exports by incorporating real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models into the decision support for the management of OMR to focus protections for fish when necessary and provide flexibility where possible, consistent with the WIIN Act Sections 4002 and 4003, as described below. Estimates of species distribution will be described by multi-agency Delta-focused technical teams. Reclamation and DWR will make a change to exports within 3 days of a trigger when monitoring, modeling, and criteria indicate protection for fish is necessary.

The following OMR Flow Management description is from the April 30, 2019 PA (Appendix A2); the primary difference from the February 5, 2019 PA (Appendix A1) is in the additional details for "Storm-related OMR Flexibility" and corrections of OMR flow requirements in the Integrated Early Pulse Protection and Turbidity Bridge Avoidance subsections.

- Reclamation and DWR propose to operate to an OMR index computed using an equation.
 An OMR index allows for short-term operational planning and real-time adjustments.
- OMR Management: From the onset of OMR management to the end, Reclamation and DWR will operate to an OMR index no more negative than a 14-day moving average of -5,000 cfs unless a storm event occurs (see below for storm-related OMR flexibility).
 OMR could be more positive than -5000 cfs if additional real-time OMR restrictions are triggered as described below.
- Onset of OMR Management: Reclamation and DWR shall start OMR management when one or more of the following conditions have occurred:

- o Integrated Early Winter Pulse Protection ("First Flush" Turbidity Event): When the running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and the running 3-day average of the daily turbidity at Freeport is 50 NTU or greater for the period from December 1 through January 31, Reclamation and DWR propose to reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period shall not be more negative than -2,000 cfs. This "First Flush" action may only be initiated once during the December through January period to limit the CVP/SWP influence on delta smelt's population-scale migration/dispersal. The action will not be required if: 1) the Freeport flow and turbidity conditions are met after January 31, or 2) water temperature reaches 12 degrees Celsius based on a three station daily mean at Honker Bay, Antioch, and Rio Vista, or 3) when ripe or spent delta smelt are collected in a monitoring survey.
- Salmonids: After January 1, if more than 5 percent of any one or more salmonid species (wild young-of-year winter-run Chinook salmon, wild young-of-year CV spring-run Chinook salmon, or wild CCV steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling.
- Additional Real-Time OMR Restrictions: Reclamation and DWR shall manage to a more positive OMR than -5,000 cfs based on the following conditions:
 - Turbidity Bridge Avoidance ("South Delta Turbidity"): In years when a "First Flush" occurs, once Delta smelt have dispersed, there is no evidence that large, population-scale movements continue. This action begins after the completion of the Integrated Early Winter Pulse Protection (above) or February 1, whichever comes first. The purpose of this action is to avoid the formation of a continuous turbidity bridge from the San Joaquin River shipping channel to the fish facilities, which historically has been associated with elevated salvage of Delta smelt. Reclamation and DWR propose to manage exports in order to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. If turbidity does not exceed 12 NTU at OBI, then there will be no explicit limit on OMR flow for the purposes of protecting Delta smelt. If daily average turbidity at OBI cannot be maintained at less than 12 NTU, the 3-day averaged OMR index shall not be more negative than -2,000 cfs, until the 3-day average turbidity at OBI drops below 12 NTU. The action is to be taken from February 1 through March 31 even if the Integrated Early Winter Pulse Protection action has not occurred earlier in the water year. The action will no longer be required on or after April 1.
 - Delta smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR propose to run hydrodynamic models informed by the Enhance Delta Smelt Monitoring program (EDSM), 20 mm trawl survey (20 mm) or other relevant survey data to estimate the percentage of larval and juvenile Delta smelt that could be entrained, and operate to avoid no greater than 10 percent loss of modeled larval and juvenile cohort Delta Smelt (typically this would come into effect beginning the middle of March).

- OWR flow of -2,500 cfs for 5 days whenever more than 5 percent of steelhead are present in the Delta and the natural-origin steelhead loss trigger exceeds 10 steelhead per TAF (combined loss at the CVP and SWP). The timing of this action is intended to provide protections to San Joaquin origin CCV steelhead, but the loss-density trigger is based on loss of all steelhead since there is currently no protocol to distinguish San Joaquin-basin and Sacramento-basin steelhead in salvage. Reclamation would use the current loss equation for steelhead or a surrogate. This action will no longer be required after May 31.
- o Salvage or Loss Thresholds: Reclamation and DWR propose a cumulative annual salvage loss threshold equal to 1 percent of the abundance estimate based on EDSM for adult Delta smelt; 1 percent of the winter-run Chinook salmon Juvenile production estimate (JPE) (genetically confirmed) or 2 percent of the winter-run Chinook salmon JPE (based on length at date); loss equal to 1 percent of the CV spring-run Chinook salmon JPE (or 0.5 percent of yearling CNFH late fall-run spring-run surrogates); the salvage of 3,000 unclipped juvenile CCV steelhead, and the salvage of 100 juvenile sDPS green sturgeon. Reclamation and DWR may operate to a more positive OMR when the daily salvage loss indicates that continued OMR of -5,000 cfs may exceed the cumulative salvage loss thresholds as described below:
 - Restrict OMR to a 14-day moving average OMR index of -3,500 cfs when a species-specific cumulative salvage or loss threshold exceeds 50 percent of the threshold. The OMR restriction to -3,500 cfs will persist until the speciesspecific off ramp is met.
 - Restrict OMR to a 14-day moving average OMR index of -2,500 cfs (or more
 positive if determined by Reclamation) when a cumulative salvage or loss
 threshold for any of the above species exceeds 75 percent of the specific
 threshold. The OMR restriction to -2,500 cfs will persist until the speciesspecific off ramp is met.

Species specific OMR restrictions will end when the individual species-specific off ramp from "End of OMR management criteria," below, are met.

- Storm-Related OMR Flexibility: If Reclamation and DWR are not implementing additional real-time OMR restrictions, consistent with other applicable legal requirements, Reclamation and DWR may operate to a more negative OMR up to a maximum (otherwise-permitted) export rate at Banks and Jones Pumping Plants of 14,900 cfs (which could result in a range of OMR values) to capture peak flows during storm-related events. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with "Additional Real-time OMR Restrictions," above.
 - Under the following conditions, Reclamation and DWR would not cause OMR to be more negative for capturing peak flows from storm-related events.

- Additional real-time OMR restrictions, above, are triggered, then Reclamation would
 operate in accordance with those additional real-time OMR restrictions and would not
 cause OMR to be more negative for capturing peak flows from storm-related events.
- Actual cumulative expanded salvage of Delta Smelt is greater than 50 percent of the
 average smelt index over the prior three years of non-zero FMWT surveys and a
 Cumulative Salvage Index of 7.98 during December 1 January 20 or cumulative
 expanded salvage of Delta Smelt is greater than or equal to 75 percent of the average
 smelt index calculated described above.
- Predicted adult or juvenile Delta Smelt salvage would exceed 50 percent during December 1 – January 20 or cumulative expanded salvage is greater than or equal to 75 percent as determined above, based on the data sources in the Secretarial Memo dated January 17, 2019.
- Measured cumulative loss to date since October 1 for winter-run Chinook salmon (based on length-at- date criteria) is greater than the percentage below of a loss threshold calculated as 2 percent of the JPE:
 - o January 1 15: 2 percent (0.04 percent of JPE)
 - o January 16 − 31: 4 percent (0.08 percent of JPE)
 - \circ February 1 14: 6 percent (0.12 percent of JPE)
 - o February 15 − 28: 9 percent (0.18 percent of JPE)
 - o March 1-15: 21 percent (0.42 percent of JPE)
 - o March 16 31: 26 percent (0.52 percent of JPE)
 - o April 1 End of OMR: 30 percent (0.60 percent of JPE)
- Predicted cumulative loss for winter-run Chinook salmon is greater than 30 percent of
 the loss threshold described above in "Additional Real-Time OMR Restrictions" [1
 percent of the Winter-Run Chinook Salmon JPE (genetically confirmed) or 2 percent
 of the Winter-Run Chinook Salmon JPE (based on length-at-date)] or salvage for
 steelhead is greater than 50 percent of the salvage threshold described above in
 "Additional Real-Time OMR Restrictions."
- Changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those described in the forthcoming biological opinion for this project.
- End of OMR Management: OMR criteria may control operations until June 30, or when both of the following conditions have occurred, whichever is earlier:
 - Delta smelt: when the daily mean water temperature at CCF reaches 25°C for 3 consecutive days.
 - Salmonids: when more than 95 percent of listed salmonids have migrated past Chipps Island, as determined by the Delta monitoring working group, <u>OR</u> after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive).

2.5.5.8.3 Assess Species Exposure to Proposed South Delta Operations – Exports and OMR Management

Note that supplemental analysis based on PA revisions received June 14, 2019 (Appendix A3) is provided in Section 2.5.5.11

The temporal and spatial occurrence of each run of Chinook salmon, CCV steelhead, and sDPS green sturgeon in the Delta is intrinsic to their natural history and summarized in Section 2.2 Status of the Species. A more detailed description of the presence of these species in the Delta is given in Section 2.5.6.1 Presence of the Species within the Bay-Delta Division. A summary of the effects of the proposed south Delta export operations is provided in Table 2.5.5-66 in Section 2.5.5.14 Summary Tables of Stressors for each Project Component.

Old and Middle River Flows – The modelling conducted for the PA (February 5, 2019; Appendix A1) depicts that OMR flows will become substantially more negative in April and May under the PA as compared to the COS due to changes in the PA compared to the NMFS 2009 Opinion. In particular, the following RPA actions influenced OMR flow values in the COS: RPA Action IV.2.1: San Joaquin River flow requirements (I:E ratio) which restricted export rates to a ratio of the inflow of the San Joaquin River as measured at Vernalis during April and May, and RPA Action IV.2.3: Old and Middle River flow management which restricted exports to manage to more positive OMR flow values for specified periods of time for the protection of listed salmonids when the exceedance of certain threshold triggers of listed fish loss occurred at the CVP and SWP fish salvage facilities.

In addition, the modelled OMR flow patterns depict more negative values for OMR in the months of January, February, March and June (Table 2.5.5-21). Furthermore, more negative OMR flows are modelled to occur in October of wet and above normal water year types with a difference of approximately 1,500 cfs under the PA as compared to the COS conditions. A similar response is modelled for January of above and below normal water year types in which the PA is approximately 700 cfs more negative than the modelled COS flows for OMR. In drier water year types, the modelling indicated that OMR flows in February and March are anticipated to be 1,000 to 1,600 cfs more negative (below normal to critical water year types) with the differences becoming greater as water year types become drier.

The shift in April and May OMR flow values between the PA and COS, as modelled, indicated that differences of approximately 4,000 cfs more negative flows would occur in wetter years. In drier years (below normal and dry water year types) the differences between the PA and COS were less, but were still approximately 1,500 cfs more negative under the PA conditions as compared to the COS conditions. In critical water year types, the PA was modelled to be 600-800 cfs more negative than the COS conditions. Seldom during the April and May period are modelled OMR flows predicted to be more positive/less negative under the PA than under the COS conditions, and positive OMR flow values occur in April and May less frequently under the PA (<10 percent of years) compared to the COS (approximately 50 percent of years). During June, the PA is modelled as being more negative by 1,000 to 1,600 cfs in drier water year types (below normal, dry, and critical).

In summary, the modelled OMR flow values for the PA indicate that for most of the winter and spring months (25 of the 30 month and water year type combinations for January through June) flows will be more negative in the channels leading to the export facilities, creating conditions that, per NMFS's conceptual model, will be more negative to fish.

Exports – In April and May, modelling indicated that combined exports would be almost twice as high for the PA as compared to the COS conditions (Table 2.5.5-22). Combined exports under the COS conditions were modelled to average 2,300 cfs in May and 2,500 cfs in April for the full simulation period. In contrast, combined exports under the PA were modelled to be 5,284 cfs in

May and 5,564 cfs in April. Differences in the export flows during April ranged from approximately 4,500 cfs in wet years to 713 cfs in critical years, with the PA flows always modelled to be greater than the COS conditions. In May, a similar trend is also seen. Differences in export flows are modelled to be approximately 4,250 cfs in wet years and 761 cfs in critical years, with the PA always having greater export flows. Average monthly combined exports are consistently greater under the PA than the COS for all months except December and July. The differences between the PA and COS range from -548 cfs in December (COS > PA) to 2,977 cfs in May (PA > COS). In almost all water year types, exports modelled for the PA are greater than for the COS conditions in October, November, January, February, March, April, and May. In wet years, exports in the PA are substantially greater in October, November, April, and May. In drier years (below normal to critical water year types) the PA typically has flows that are 1,000 cfs or greater than the COS conditions for the January through June period. These increases in combined export flows mirror the trends seen in the modelling done for the OMR flows as would be expected.

Velocity Density Modelling – The results of the velocity density modelling parallel the trends already exhibited for OMR and combined export modelling. In locations along the Old and Middle river routes, density plots show a shift to more negative velocities in the March through May periods for river reaches adjacent to the export facilities. Modelling for the velocity density comparisons used 3-month bins: December through February, March through May, June through August, and September through November. The 3-month bin for the modeling obscures the details of the effects of exports and reverse flows in Old and Middle rivers on a monthly basis as was presented earlier. The shift to more negative velocity values in the March through May period for the Old River and Middle River channel segments (89, 90, and 143) indicate the hydrodynamic effects of the increased combined exports and mirrors the resulting trends seen in the OMR flow values for the modelled PA conditions. Greater exports would tend to create more negative OMR flows given the same inflow and tidal conditions, and given that the geometry of the channel segments used in the modelling should remain consistent, increased negative flow should result in more negative velocity values in those channels.

For example, the velocity density plots for Old River at Highway 4, and just upstream towards the export facilities (channels 89 and 90) show a shift to more negative velocities in the March through May period for all water year types. Similar trends are seen for Middle River at Woodward Island (channel 143) and Old River near Woodward Island (channel 95). The percentage of overlap between the modeled PA and COS conditions is typically greater for drier years (conditions are more similar) than for wetter years (more dissimilar), which parallels the greater difference in total exports and OMR flows seen in the wetter years compared to drier years.

2.5.5.8.3.1 South Delta Salvage and Entrainment

Entrainment of juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon at the south Delta export facilities may result in mortality. "Loss" is a term used to refer to the estimated number of fish that experience mortality within the fish collection facilities as they go through the salvage process, and is estimated based on the number of salvaged fish (fish observed within the fish collection facilities at the export facilities) and a number of components related to facility efficiency and handling. For example, at the SWP, the salvage process starts with fish entrainment into CCF, and proceeds with fish moving

across the CCF until they enter the SDFPF, where they are collected in holding tanks. After fish collection, a subsample is counted for determining the number of fish salvaged in a given period of time. This is usually represented by a 30-minute subsample of a 2-hour block of fish collections. After this stage, fish are transferred to tanker trucks and driven to releases sites in the western Delta and released back into the Sacramento or San Joaquin rivers. At the CVP, the fish salvage process is considered to start with fish encountering the trash rack on Old River in front of the primary channel, and then progressing through the salvage process until the salvaged fish are ultimately releases at the release sites, similar to the process at the SDFPF. In the following description, percentages refer to the percent of fish reaching a specific stage in the salvage process that are assumed to experience mortality during that stage. For example, the 75 percent loss associated with prescreen loss at the SWP means that 75 percent of the fish entering CCF at the radial gates are assumed to die before reaching the primary louvers at the SDFPF. Of those fish that do reach the louvers, another 25 percent are lost, and so on. The total loss percentages represent the overall percent loss across all stages, that is, the percent of all fish entering the facility that die somewhere during the salvage process.

- SWP: (1) Prescreen loss (from CCF radial gates to primary louvers at the SDFPF): 75 percent loss, (2) Louver efficiency: 25 percent loss; (3) Collection, handling, trucking, and release: 2 percent loss; (4) Post release: 10 percent loss; and (5) Total loss (combination of the above): 83.5 percent.
- CVP: (1) Prescreen loss (in front of trash racks and primary louvers): 15 percent loss; (2)
 Louver efficiency: 53.2 percent loss; (3) Collection, handling, trucking, and release: 2
 percent loss; (4) Post release: 10 percent loss; and (5) Total loss (combination of the above): 64.9 percent.

For purposes of evaluating the effect of near-field south Delta exports on Chinook salmon, steelhead, and green sturgeon, NMFS presents juvenile loss data using: (1) historical salvage and loss data; and (2) salvage-density method as modelled.

NMFS provides a quantitative analyses of entrainment differences between COS and PA using the salvage density methodology, and a qualitative discussion of potential predation differences between COS and PA. The salvage-density method (Appendix G) relies on historic export rates and observed loss of salmonids and sturgeon at the CVP and SWP collection facilities (for water years 1995-2009). This period represents a hydrologic regime that predates the 2009 Biological Opinion and does not reflect the -5,000 OMR restriction (or other operations) in either the PA or COS. This period was what was used in the equivalent modeling for the California WaterFix consultation and the accelerated timeframe of the current consultation didn't allow for the method to be updated to include more recent years. The method essentially functions as a description of changes in export flows weighted by seasonal changes in loss. While the model is designed as a comparative tool, NMFS does use the absolute estimates of loss to put the potential effect into a population context for CV spring-run Chinook salmon and CCV steelhead, but those results should be considered a coarse screening level analysis due to limitations of the salvagedensity method itself (limited historical time-frame of loss; relatively simple weighting of loss by export changes and no other operational factors) and use of the average annual modeled loss rates (over the 15-year data period) scaled to both low and high population estimates. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the

average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

2.5.5.8.3.1.1 Sacramento River Winter-run Chinook salmon exposure

Fish entrained at the state and Federal fish collection facilities that reach the salvage tanks are collected and transported back to the Delta from both the state and Federal water projects. A screened subsample of fish that reach the salvage tanks are sampled every 2 hours and the total fish salvage per each sampling period is calculated by expanding the number of fish salvaged by the fraction of time that diversions were sampled. Fish loss for that period of time is calculated based on the standard loss equations (CDFW 2013; available at the CDFW website: ftp://ftp.dfg.ca.gov/salvage/Salmon%20Loss%20Estimation/). Daily salvage and loss is the cumulative sum for those metrics for all of the sampling periods that occurred in that given day. Historical salvage and loss data analysis is presented in Table 2.5.5-24 and Table 2.5.5-25 to provide context for the loss estimates for the PA and COS based on the salvage density method.

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the average annual adipose fin clipped juvenile winter-run Chinook salmon (hatchery-produced fish) salvage and loss from brood years 1999 to 2017 were estimated to be 1,428 and 3,976 juveniles, respectively (Table 2.5.5-24). The average proportional loss, which is the annual total loss of clipped juvenile winter-run Chinook salmon divided by the annual number of hatchery-reared and released juvenile winter-run Chinook salmon, was 2.39 percent (Table 2.5.5-24). The average between 1999 and 2008 was 4.08% while the average from 2009-2017 was 0.52%.

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the average annual unclipped juvenile winter-run sized Chinook salmon salvage and loss from brood years 1992 to 2017 were estimated to be 1,205 and 3,201 juveniles, respectively (Table 2.5.5-25). The average proportional loss of unclipped juveniles, which is the annual total loss of unclipped juveniles divided by the annual juvenile production estimate (JPE) of juvenile winter-run Chinook salmon, was 1.01 percent (Table 2.5.5-25). The average between 1992 and 2008 was 1.35% while the average from 2009-2017 was 0.36%.

2.5.5.8.3.1.1.1 Juvenile Salvage Estimates using the Salvage-Density Method

The salvage density method relies on historic exports and observed loss (for water years 1995-2009) of salmonids at the CVP and SWP fish salvage facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in loss (see caveats in Section 2.5.5.8.3.1). The results of the salvage-density method showed that, based on modeled south Delta exports, annual loss of winter-run Chinook salmon at the south Delta export facilities would be 7 percent (in Above Normal water year types) to 38 percent (in Critical water year types) higher under the PA than the COS (Table 2.5.5-26). The monthly loss of winter-run Chinook salmon at the south Delta export facilities (Table 2.5.5-27) shows that while loss does increase by a high percentage in April and May, the historical pattern is that the majority of winter-run Chinook salmon salvage occurs before April. It is possible that some of the loss modeled to occur at the export facilities under the PA flow conditions might have occurred due to far-field effects in the south Delta under COS conditions, but no modeling tool is available

that allows estimation of and comparison of independent estimates of direct loss and far-field effects under the PA vs. COS. Fish that may have been predated upon or otherwise lost in far field areas under the influence of the Project operations in the COS scenario (i.e., migrational delay, increased transit time, increased predator exposure) may arrive at the fish salvage facilities under the PA scenario due to faster transit times in the adjacent river routes, thus having less exposure to predators, only to be lost in the salvage process at the fish facilities. While we do have information on reach-scale survivals and travel-times, our current understanding of subdaily, fine scale fish movement within a reach (and associated survival outcomes) is limited since no study has deployed sufficient instrumentation to track fine scale movement and fish survival outcomes. Tools such as the Delta Passage Model provide estimates of total through-Delta survival. While results of that model (described previously) show negligible changes in overall survival between the PA and COS, that model doesn't capture effects to San Joaquin-origin populations of listed salmonids.

The absolute differences between the PA and the COS were greater in wetter water years, as a result of more south Delta export pumping, however a greater percentage difference between the estimated loss occurred in drier water year types (Table 2.5.5-28). For winter-run Chinook salmon, the differences ranged from 5.3 percent more under the PA at the SWP in above normal years to 45.3 percent more under the PA at the CVP in critical years (Table 2.5.5-28). Within years, the monthly estimated loss varied considerably. The estimated loss rates were typically higher from January through May for all water year types for the PA compared to the COS. However, February and March had lower loss values in wet years for the PA compared to the COS conditions, but higher values in drier years (Table 2.5.5-29, Table 2.5.5-30, Table 2.5.5-31, Table 2.5.5-32, and Table 2.5.5-33). The largest percentile differences between the PA and COS occurred in April, where the PA loss rate could be as much as 238 percent higher than the COS conditions [above normal years at the SWP (Table 2.5.5-30)] and loss values were typically 100 percent higher for the other water year types. This difference reflects the substantial increase in exports during April under the PA compared to the COS conditions.

Increased entrainment into the south Delta fish collection facilities would decrease migratory success for winter-run Chinook salmon that are exposed to the export facilities in the waterways immediately adjacent to the facility intakes and that do not migrate through the salvage facilities. An increased negative flow in the region immediately adjacent to the intakes to the CCF and the CVP would increase the probability of fish being unable to reverse course and successfully exit the Delta, although the magnitude of this effect is currently unknown due to a lack of data regarding fine scale, reach specific fish movement behavior and survival in those reaches under increased export conditions. Increased pumping has far-field migratory impacts as well, particularly in the Old and Middle River corridors which would negatively affect winter-run Chinook salmon in those corridors. Fish that are present in the Old River or Middle River corridors and their distributaries downstream of the south Delta export facilities would experience increased net flows towards the export facilities. Increased exports would obscure more of the ebbing tide signal that would normally cue fish to move out of those corridors and back into the main migratory corridor of the San Joaquin River before moving southwards into waters that are more heavily influenced by the effects of reverse flows due to exports.

An important concept to note is that even though the numbers of fish lost in the drier water year types may be lower than during wetter water year types, this is a function of overall watershed survival differences between water year types. During wet water years, more juvenile salmonids

enter the south Delta from either basin and greater numbers are therefore exposed to the export facilities (Kjelson et al. 1982, Brandes and McLain 2001, Newman and Brandes 2010). Lower numbers of fish salvaged in drier years, therefore, does not necessarily indicate that restrictions on pumping are impacting a smaller proportion of fish. Often the OMR flows are more negative in dry years even if exports are reduced. In dry years, less water is flowing into the Delta from tributaries, and in particular the San Joaquin River basin. Less flow into the HOR will exacerbate the effects of exports since there is less flow moving downstream from the HOR towards the CVP and SWP intakes to offset the volume of water being diverted, and more water will have to come from alternative sources, such as the waters of the central Delta to supply the volume of water being exported. Conversely, it is possible to be exporting to full capacity in the wet years and OMR flows are still positive due to very high San Joaquin River and tributary flows, which can completely offset the volume of water being diverted by the CVP and SWP.

Furthermore, NMFS does have concerns that in drier years, under lower flows in the Sacramento River, a greater proportion of fish will enter the central Delta due to the greater effect of reverse flows created from tidal influence. This greater proportion of fish that enter the Delta interior are expected to have a lower survival rate and also have exposure to the effects of the south Delta exports. Conversely, in wetter years with more flow in the Sacramento River, the riverine reach of the mainstem Sacramento River extends farther downstream and less fish are routed into the central Delta, remaining in the mainstem instead. Regional flows in south Delta waterways are expected to remain strongly affected by any export actions in drier water year types, which in turn increases the likelihood that out-migrating juvenile winter-run Chinook salmon will be negatively affected by exports.

2.5.5.8.3.1.2 CV Spring-Run Chinook Salmon Exposure

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the estimate of average annual adipose fin clipped CV spring-run Chinook salmon juvenile salvage and loss from brood year 1999 to 2017 were 667 and 1,406 juveniles (Table 2.5.5-34), respectively, for the SWP and CVP combined. The estimated average proportional loss, which is the estimated annual total loss divided by the annual number of hatchery-reared and released CV spring-run Chinook salmon juveniles, was 0.63 percent (Table 2.5.5-34).

The estimated cumulative SWP and CVP average annual unclipped CV spring-run sized Chinook salmon juvenile salvage and loss from brood year 1992 to 2017 using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, were 14,062 and 26,241 juveniles (Table 2.5.5-35), respectively.

2.5.5.8.3.1.2.1 Juvenile Salvage Estimates using the Salvage-Density Method

The salvage density method relies on historic exports and observed loss (for water years 1995-2009) of salmonids at the CVP and SWP fish salvage facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in loss (see caveats in Section 2.5.5.8.3.1). The historical loss pattern used in the Salvage-Density modeling identified fish to run based on length-at-date (LAD) criteria. Because of run-assignment error associated with the LAD criteria, much of projected spring-run-sized loss may not represent genetic CV

spring-run Chinook salmon loss, but rather represent loss of (primarily) unmarked hatchery fall-run. Harvey and Stroble (2013) reported that 98 percent of the spring-run-sized fish in their sample were not genetic spring-run (95 percent genetic fall-run, 1 percent genetic winter-run, and 2 percent genetic late-fall-run). In order to generate a loss estimate more representative of genetic CV spring-run Chinook salmon, we multiplied the projected loss numbers by 0.02 and refer to the outcome as "adjusted loss."

The results of the salvage-density method showed that, based on modeled south Delta exports, annual adjusted loss of CV spring-run Chinook salmon at the south Delta export facilities would be 64 percent (in Critical years) to 159 percent (in Above Normal years) higher under the PA than the COS (Table 2.5.5-36). The monthly loss of CV spring-run Chinook salmon at the south Delta export facilities (Table 2.5.5-36) shows that the largest increases in loss occur in April (143 percent), and May (128 percent). The majority of CV spring-run Chinook salmon outmigration occurs during the April-May period, so the risk of increased loss during April and May will affect the majority of CV spring-run Chinook salmon outmigrants. It is possible that some of the loss modeled to occur at the export facilities under the PA flow conditions might have occurred due to far-field effects in the south Delta under COS conditions before fish arrived at the CVP or SWP facilities. Some of this far-field loss may be attributable to the effects of the SWP and CVP export operations, but no modeling tool is available that quantifies that loss and allows comparison of both direct loss and far-field effects under PA vs. COS conditions associated with the SWP and CVP export operations.

NMFS put the combined CV spring-run Chinook salmon loss in a population context (see full caveats in Section 2.5.5.8.3.1) by expressing the estimated annual combined loss as a percentage of the juvenile CV spring-run Chinook salmon entering the Delta. These results should be considered a coarse screening level analysis due to limitations of the salvage-density method itself (limited historical time-frame of loss; relatively simple weighting of loss by export changes and no other operational factors) and use of the average annual modeled loss rates (over the 15-year data period) scaled to both low and high population estimates. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

Assuming that the relationship between spring-run escapement and number of juveniles entering the Delta is similar to that for winter-run Chinook salmon 14 (Table 2.5.5-38), the observed Brood Year 2010-2018 tributary CV spring-run Chinook salmon escapement range of 1,059 to 19,516 is estimated to produce 35,334 to 3,837,720 juvenile CV spring-run Chinook salmon entering the Delta. The estimated annual combined loss from the COS is 851 juveniles, and estimated annual combined loss from the PA is 1,732. Applying the estimated annual combined loss to the lowest and highest juvenile population estimates provides ranges of <1 (851 \div 3,837,720) to 2 (851 \div 35,334) percent loss of the juvenile CV spring-run Chinook salmon population in the Delta for the COS, and <1 (1,732 \div 3,837,720) to 5 (1,732 \div 35,334) percent loss of the juvenile CV spring-run Chinook salmon population in the Delta for the PA. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate

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¹⁴ Mortality during spawning, egg incubation, and juvenile rearing and migration may differ between spring-run and winter-run Chinook salmon since the seasonal timing of those life history stages don't fully overlap, but we used this assumption since winter-run Chinook salmon is the only salmonid for which there is an estimate of juveniles entering the Delta.

likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

The results of the salvage-density method showed that, based on modeled south Delta exports, mean loss at the south Delta export facilities would be substantially higher under the PA than the COS in all water year types for CV spring-run Chinook salmon. The absolute differences and percentile differences between the PA and the COS were greater in wetter water years, as a result of more south Delta export pumping (Table 2.5.5-39). For CV spring-run Chinook salmon, the differences ranged from 28.2 percent more under the PA at the CVP in critical years to 167.5 percent more under the PA at the SWP in above normal years (Table 2.5.5-39). Within years, the monthly estimated loss varied considerably. The estimated loss rates were typically higher from March through May for drier year types for the PA compared to the COS. However, March had lower loss values in wet years for the PA compared to the COS conditions, but higher values in drier years (Table 2.5.5-40, Table 2.5.5-41, Table 2.5.5-42, Table 2.5.5-43, and Table 2.5.5-44). The largest percentile differences between the PA and COS occurred in April, where the PA loss rate could be as much as 238 percent higher than the COS conditions [above normal years (Table 2.5.5-45)] and loss values were typically 80 percent higher for the other water year types. This difference reflects the substantial increase in exports during April under the PA compared to the COS conditions.

As discussed previously for winter-run Chinook salmon juveniles, there are many issues that influence the movement and vulnerability of juvenile CV spring-run Chinook salmon to entrainment, salvage, and loss at the fish collection facilities for the CVP and SWP. Like winter-run Chinook salmon, the majority of CV spring-run Chinook salmon originate in the Sacramento River basin and, thus, follow a common emigration pathway to the Delta through the main stem of the Sacramento River. Factors which influence the routing and survival of winter-run Chinook salmon juveniles will also influence the routing and survival of juvenile CV spring-run Chinook salmon. A further issue, that does not apply to juvenile winter-run Chinook salmon is the emigration of juvenile CV spring-run Chinook salmon out of the San Joaquin River basin (originating from the experimental population) and the necessity of surmounting obstacles unique to the San Joaquin River basin, including the actions of the south delta agricultural barriers, and migrating through the waterways of the south Delta as the primary route to the ocean and not as a secondary route as seen for the Sacramento River basin fish.

Increased entrainment into the south Delta facilities is expected to decrease migratory success for CV spring-run Chinook salmon that are exposed to the pumping plants in the waterways immediately adjacent to the facility intakes. A more negative flow environment in the region immediately adjacent to the intakes of the CCF and the CVP would decrease the probability of fish being able to alter course and successfully exit the Delta, although the magnitude of this effect is currently unknown due to a lack of data regarding fine scale fish movement behavior and survival in those reaches under export conditions. This is particularly important for CV spring-run Chinook salmon that originate in the San Joaquin River basin and enter the Old River channel when there is no HOR barrier present as proposed under the PA. These fish would migrate downstream in either the Old River, Middle River, or Grant Line/ Fabian – Bell channels have considerable exposure to the effects of exports. The Old River and Grant Line/ Fabian –Bell channels pass directly in front of or in very close proximity to the intakes for the CVP and SWP, and a large proportion of fish moving through these channels are expected to be entrained into the fish collection facilities where high levels of mortality are

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expected. The Middle River channel joins with the man-made Victoria Canal/ North Canal, a large dredged channel directly leading to the export facilities, and net flows move towards the export facility intakes under most conditions.

Increased export has negative far-field migratory impacts as well, particularly in the Old and Middle River corridors which would negatively affect CV spring-run Chinook salmon in those corridors. Fish that are present in the Old River or Middle River corridors and their distributaries downstream of the south Delta export facilities would experience increased net flows towards the export facilities. Increased exports would mute the ebbing tide signal to cue fish to move out of those corridors and back into the main migratory corridor of the San Joaquin River rather than moving farther southwards into waters that are more heavily influenced by the effects of reverse flows due to exports. This would affect both juvenile CV spring-run Chinook salmon originating in the Sacramento River basin as well as those CV spring-run Chinook salmon originating in the San Joaquin River basin and migrating downstream within the main stem channel of the San Joaquin River from upstream locations.

The PA does not include installation of the HOR barrier, which will result in keeping less flow in the San Joaquin River corridor, thereby decreasing survival for CV spring-run Chinook salmon originating in the San Joaquin River basin and entering the South Delta and interior Delta through this route. There are two main reasons for these impacts. Less downstream flow in the San Joaquin River channel downstream of the confluence with the HOR in conjunction with increased exports was modeled to slightly shift the velocity density to more negative velocities (more upstream flows), potentially indicating more tidal effect in this reach under the PA (Figure 2.5.5-30). This shift in tidal influence tends to direct more flow (and migrating fish) into Old River due to the tidal forcing of the flood tide moving upriver in the main stem of the San Joaquin River. The modeling of the velocity density indicated that within the main stem San Joaquin River near its junction with the Mokelumne River and farther downstream at Jersey Point, there was a high degree of overlap between the PA and COS due to the overwhelming tidal influence. Therefore, in this portion of the main stem San Joaquin River, there is little difference between the PA and the COS. However, survival in these reaches are considered to be low due to the influence of the tides prolonging migration transit times and increasing exposure to predators along the route.

As discussed in the winter-run Chinook salmon section above, it is an important concept to note that even though the absolute numbers of fish lost in the drier water year types under current conditions are lower than during wetter water year types, this is also a function of overall watershed survival differences between water year types as well as the magnitude of exports. During wet water years, more juvenile salmonids enter the south Delta from either basin and greater numbers are, therefore, exposed to the export facilities (Kjelson et al. 1982, Brandes and McLain 2001, Newman and Brandes 2010). Lower numbers of fish lost in drier years, therefore, does not necessarily indicate that restrictions on pumping are impacting a smaller proportion of fish, but that there is potentially a smaller pool of fish present to be entrained. The effects of more negative OMR flows have already been discussed for winter-run Chinook salmon and NMFS expects that they will have similar impacts upon CV spring-run Chinook salmon.

2.5.5.8.3.1.3 CCV Steelhead Exposure

Using the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers, the estimated average annual cumulative clipped juvenile CCV steelhead salvage and loss from brood year 1999 to 2017 for the SWP and CVP were 2,798 and 6,990 juveniles, respectively (Table 2.5.5-45). The average proportional loss for the years 1999-2014 (incomplete hatchery release data were available for 2015-2017), which is the annual cumulative total loss divided by the annual number of hatchery-reared and released steelhead juveniles, was 0.50 percent (Table 2.5.5-45). Since 1998, all hatchery-produced steelhead that are released into the waters of the Central Valley are adipose fin clipped to allow them to be distinguished from natural fish. The average annual cumulative unclipped (natural) juvenile CCV steelhead salvage and loss from brood year 1999 to 2017 for the SWP and CVP were 1,324 and 3,110 juveniles, respectively (Table 2.5.5-46).

As discussed previously for juvenile winter-run Chinook salmon and CV spring-run Chinook salmon, there are many issues that influence the movement and vulnerability of juvenile CCV steelhead to entrainment, salvage, and loss at the fish collection facilities for the CVP and SWP. Comparable to the winter-run Chinook salmon and CV spring-run Chinook salmon populations, the majority of CCV steelhead originate in the Sacramento River basin and, thus, follow a common emigration pathway to the Delta through the main stem of the Sacramento River. Factors which influence the routing and survival of Chinook salmon juveniles will also influence the routing and survival of juvenile CCV steelhead. Like juvenile spring-run originating from the experimental population in the San Joaquin River basin, juvenile CCV steelhead emigrating out of the San Joaquin River basin (Southern Sierra diversity group) face the necessity of surmounting obstacles unique to the San Joaquin River basin, including the actions of the south Delta agricultural barriers, and migrating through the waterways of the south Delta as the primary route to the ocean and not as a secondary route as seen for the Sacramento River basin fish.

The discussion of the effects of south Delta export facilities operations that has already been described for winter-run Chinook salmon and CV spring-run Chinook salmon would be applicable to CCV steelhead. Juvenile CCV steelhead migration through the Delta overlaps with both the migration timing of winter-run Chinook salmon and CV spring-run Chinook salmon, and, therefore, the discussion from both Chinook salmon races would be expected to apply to CCV steelhead, too. In the San Joaquin River basin, comparisons to CV spring-run Chinook salmon are especially appropriate, as NMFS expects juveniles from both salmonid groups will be migrating out of the San Joaquin River basin at the same time and will experience the same hydrologic and operational effects during their movements.

2.5.5.8.3.1.3.1 Juvenile Salvage Estimates using the Salvage-Density Method

The salvage density method relies on historic exports and observed loss (for water years 1995-2009) of salmonids at the CVP and SWP collection facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in loss (see caveats in Section 2.5.5.8.3.1). The results of the salvage-density method showed that, based on modeled south Delta exports, annual loss of CCV steelhead at the south Delta export facilities would be 15 percent (in Above Normal years) to 38 percent (in Critical years) higher under the PA than the COS (Table 2.5.5-47). The monthly loss of CCV steelhead at the south Delta export facilities

(Table 2.5.5-48) shows that the largest increases in loss occur in April (153 percent), and May (132 percent). The majority of steelhead outmigration from the San Joaquin Basin occurs during the April-May period, so while much overall steelhead salvage occurs prior to April, the risk of increased loss during April and May will affect the majority of San Joaquin-origin steelhead outmigrants. It is possible that some of the loss modeled to occur at the export facilities under the PA flow conditions might have occurred due to far-field effects in the south Delta under COS conditions before fish arrived at the CVP or SWP facilities. Some of this far-field loss may be attributable to the effects of the SWP and CVP export operations, but no modeling tool is available that quantifies that loss and allows comparison of both direct loss and far-field effects under PA vs. COS conditions associated with the SWP and CVP export operations.

NMFS put the combined CCV steelhead loss in a population context (see full caveats in Section 2.5.5.8.3.1) by expressing the estimated annual combined loss as a percentage of the steelhead population in the Delta. These results should be considered a coarse screening level analysis due to limitations of the salvage-density method itself (limited historical time-frame of loss; relatively simple weighting of loss by export changes and no other operational factors) and use of the average annual modeled loss rates (over the 15-year data period) scaled to both low and high population estimates. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

Estimated annual combined loss from the COS is 6,560 juveniles, and estimated annual combined loss from the PA is 7,988. Good et al. (2005) estimated the CCV steelhead population at approximately 94,000-336,000 juveniles, and Nobriga and Cadrett (2001) estimated the CCV steelhead population at 413,069-658,453 juveniles. Applying the estimated annual combined loss to the lowest and highest juvenile population estimates provides ranges of 1 (6,560 \div 658,453) to 7 (6,560 \div 94,000) percent loss of the juvenile CCV steelhead population in the Delta for the COS, and 1 (7,988 \div 658,453) to 8 (7,988 \div 94,000) percent loss of the juvenile CCV steelhead population in the Delta for the PA. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year.

The results of the salvage-density method showed that, based on modeled south Delta exports, mean loss at the south Delta export facilities would be higher under the PA than the COS in all water year types for CCV steelhead. The absolute differences between the PA and the COS were similar in most water year types (1,250 to 1,600 fish), except in dry years when the difference between the PA and COS was estimated as 2,249 fish for the SWP and 486 for the CVP (Table 2.5.5-49). For CCV steelhead, the differences ranged from 13.3 percent more under the PA at the CVP in below normal years to 38.8 percent more under the PA at the SWP in critical years (Table 2.5.5-49). Within years, the monthly estimated loss varied considerably. The estimated loss rates were typically higher in April and May for all water year types for the PA compared to the COS. However, March had lower loss values in wet years for the PA compared to the COS conditions, but higher values in drier years (Table 2.5.5-50, Table 2.5.5-51, Table 2.5.5-52, Table 2.5.5-53, and Table 2.5.5-54). The largest percentile differences between the PA and COS occurred in April and May, where the PA loss rate could be as much as 238 percent higher than the COS conditions (April, above normal years and below normal years [Table 2.5.5-51 and

Table 2.5.5-52]) and loss values were typically at least 75 percent higher for the other water year types. This difference reflects the substantial increase in exports during April and May under the PA compared to the COS conditions.

2.5.5.8.3.1.4 sDPS Green Sturgeon Exposure

In recent years (2011-2018) only 8 green sturgeon have been observed in salvage, 4 at the SWP (2016) and 4 at the CVP (2017). For the period from 1981 to 2018, the estimated annual cumulative expanded salvage of green sturgeon between the CVP and SWP has ranged between 0 and 1,476 fish, with a mean annual cumulative salvage of 200 fish using current methods for expanding salvage counts. However, since the late 1980s, annual salvage has been substantially less than this.

2.5.5.8.3.1.4.1 Juvenile Salvage Estimates using the Salvage-Density Method

The salvage density method relies on historic exports and observed salvage (for water years 1995-2009) of sturgeon at the CVP and SWP fish salvage facilities and essentially functions as a description of changes in export flows weighted by seasonal changes in salvage (see caveats in Section 2.5.5.8.3.1). The results of the salvage-density method showed that, based on modeled south Delta exports, average sDPS green sturgeon salvage at the south Delta export facilities would be slightly higher under the PA than the COS. The biggest differences would occur in wet years with the PA modelled as having between 4.4 percent (SWP) and 9.3 percent (CVP) more fish salvaged during wet water year types. Due to the rarity of sDPS green sturgeon in salvage, these numbers are typically represented by only a very small numbers of fish (Table 2.5.5-55, Table 2.5.5-56, Table 2.5.5-57, Table 2.5.5-58, Table 2.5.5-59, and Table 2.5.5-60).

2.5.5.8.4 Species responses to OMR Flow Management

Note that supplemental analysis based on PA revisions received June 14, 2019 (Appendix A3) is provided in Section 2.5.5.11

The following discussion addresses the potential responses of listed salmonids and sDPS green sturgeon to the proposed OMR flow management plan. As previously stated, increasing exports increases the probability of fish entrainment into the fish salvage facilities through alterations in the near- and far-field hydrodynamics of the south Delta. Measuring OMR flows is a proxy for determining the influence of exports and Vernalis inflow on the local hydrodynamic field surrounding the export facilities in the south Delta waterways.

2.5.5.8.4.1 Onset of OMR Flow Management

The OMR flow management PA (April 30, 2019; Appendix A2) component requires several assumptions to be made for its implementation. The following assumptions are made regarding the implementation of this PA component:

- The Delta monitoring group assesses the percentage of population present in the Delta in a manner similar to the current DOSS group.
- Similar or better information is available to the Delta monitoring group.

2.5.5.8.4.1.1 Integrated Early Water Pulse Protection (First Flush) Turbidity Event

Although this PA component is specifically designed to protect Delta smelt during their upstream movements prior to spawning, it may provide protective benefits to emigrating juvenile salmonids. This PA component will be implemented following a "First Flush" event in the Delta that is triggered when there are flows greater than 25,000 cfs on the Sacramento River, as measured at Freeport on a 3-day running average coupled with a 3-day running daily average turbidity of 50 NTU at Freeport during the period of December 1 through January 31. The PA component may only occur once during this period. If the required conditions exist, Reclamation and DWR will reduce exports for 14 consecutive days to achieve an OMR index flow that will be no more negative than -2,000 cfs¹⁵ over the 14-day averaged flow. The reduced export environment will be beneficial to any listed salmonids or sDPS green sturgeon in the vicinity of the export facilities that could encounter near-field or far-field effects of the exports. A more positive OMR would be expected to change the local hydrodynamics resulting in reduced entrainment into the facilities, and reduced alterations to the routing of migrating fish into the south delta region from the north.

As previously stated in this document, during the period of the "First Flush" PA component from December 1 through January 31, juvenile winter-run Chinook salmon and yearling CV springrun Chinook salmon would be expected to initiate their emigration into the Delta when precipitation events in the upper Sacramento River watershed cause flows in the main stem to increase substantially. Flows in excess of approximately 14,000 cfs on the Sacramento River (as measured at Wilkins Slough) have been shown to be an indication that emigration of juvenile winter-run Chinook salmon will occur (del Rosario et al. 2013). Similarly, increases in flows in Sacramento River tributaries such as Deer Creek and Mill Creek over 95 cfs have been correlated with emigration of yearling CV spring-run Chinook salmon juveniles from those watersheds. The triggers described for the "First Flush" protective PA component would also indicate that environmental conditions are present that would stimulate emigration of listed salmonids (winter-run Chinook salmon and yearling CV spring-run Chinook salmon) into the Delta. The amount of overlap between the initiation of salmonid emigration and the "First Flush" PA component would depend upon the timing of storm events and flows in the Sacramento River. If the first major storm event of the winter rainy season occurred during the December through January implementation period, and produced the appropriate flow and turbidity conditions to trigger the "First Flush" PA component, then there would be a high level of overlap between winter-run Chinook salmon and yearling CV spring-run Chinook salmon emigration and the protective PA component. On the other hand, if smaller storms came through earlier in the season that did not create the conditions necessary to trigger the "First Flush" PA component, but were sufficient to raise Sacramento River flows over 14,000 cfs at Wilkins Slough, then the expectation is that salmonid emigration will have already started and the overlap with the "First Flush" PA component will not occur to the same extent if conditions eventually occur later in the season that trigger the action. It is also possible that the conditions to initiate the "First Flush" will not occur in a given year, and thus there is no protective PA component taken and no benefits to listed salmonids of the reduced exports.

¹⁵ At a May 21, 2019, consultation meeting on the Delta, Reclamation confirmed the OMR limit during a "First Flush" event should be -2,000 cfs.

2.5.5.8.4.1.2 Salmonid Onset Triggers

Reclamation and DWR proposed that OMR flows will be no more negative than -5,000 cfs after January 1 if more than 5 percent of any one or more unclipped listed salmonid species (winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead) are estimated to be present in the Delta as determined by "real-time" monitoring data and the advice of a Delta-specific working group. The PA component incorporates a percentage of listed salmonid population in the Delta metric to initiate OMR management and that management of OMR flows cannot start any earlier than January 1. It is possible under this new metric that management of OMR flow levels may not start on January 1, if none of the listed salmonid species has at least 5 percent of the population in the Delta by January 1. If this condition exists, these listed fish in the Delta would not have any of the protections afforded by an OMR management action that maintains flows at no more negative than -5,000 cfs.

The Salmonid Scoping Team was asked to evaluate the effectiveness of the OMR onset criteria in the NMFS 2009 CVP/SWP Operations opinion which is reflected in the COS scenario. Since January 1 plays a role in both the COS and the PA, NMFS considers that evaluation relevant for understanding the potential effects of the PA on salmonids and reviews those results here. The Salmonid Scoping Team (2017b) concluded that the "January 1 onset of OMR reverse flow management coincides with the presence of protected salmonids in the Delta in almost all years, but an earlier onset would often be more effective for some listed salmonids. The January 1 trigger date provides a general approximation of a date by which juvenile winter-run Chinook have likely entered the Delta and, based on its simplicity for triggering management actions, has utility." Furthermore, the Salmonid Scoping Team (2017b) reported that "while initiating OMR flow restrictions on January 1 each year provided protection, initiating the restrictions prior to January 1 would have provided better protection for winter-run Chinook salmon. This is because these fish were detected prior to January 1 in the Delta in all but one year from 1995 to 2015." The Salmon Scoping Team concluded that "in most years, improved protection of Sacramento River salmonid populations from export effects would be provided if the onset date of OMR reverse flow management were triggered by detection of migrants at monitoring stations located on the Sacramento River upstream of distributary junctions leading toward the San Joaquin River."

Based on the historical record, winter-run Chinook salmon are the listed salmonid species most likely to be in the Delta on January 1 with more than 5 percent of its brood year population present. Using the information from the retrospective compilation of data from Sacramento trawls at Sherwood Harbor, the average date by which 5 percent of the population passes Sherwood Harbor (site of the Sacramento trawls) is December 17 (median date December 11). On average, 25 percent of the winter-run population is in the Delta by January 9 (median date December 29) which indicates that for the endangered winter-run Chinook salmon population, approximately 20-25 percent of the population is already in the Delta prior to any protective OMR flow management actions being implemented on January 1 (Table 2.5.5-11). The timing of CV spring-run Chinook salmon and CCV steelhead emigrations indicate that these populations do not enter the Delta (based on the Sacramento trawl data) until the end of January and into early February (Table 2.5.5-12 and Table 2.5.5-13). OMR flow management actions are not taken for any life stage of sDPS green sturgeon, as they are assumed to be present in the Delta year-round. Real time estimates of listed salmonid presence in the Delta by the DOSS working group only includes natural juvenile winter-run Chinook salmon and CV spring-run Chinook salmon. The DOSS working group currently does not make any estimates of the distribution of

the wild juvenile CCV steelhead population, given the difficulty of monitoring for this species. Juvenile CCV steelhead are difficult to capture in the trawls and RSTs used in the Central Valley monitoring programs as they can easily avoid them, thus making any assessment to population distribution uncertain.

The proposed onset of OMR based on salmonid triggers, for the most part, would not often be different than current operations under the COS conditions, with OMR flow management restrictions likely starting on January 1 except in the driest of years when juvenile migration occurs after January 1. Listed salmonids entering the Delta prior to January 1 would not have any protection from elevated exports, and may be exposed to OMR flows more negative than -5,000 cfs unless first flush conditions have triggered an OMR action that targets protecting Delta Smelt

In those infrequent years when emigration of winter-run Chinook salmon is delayed by upstream flow conditions, the entry of the bulk of the juvenile winter-run Chinook salmon population into the Delta would be delayed until precipitation events create the right conditions to stimulate emigration. However, a proportion of the winter-run Chinook salmon population (and likely yearling spring-run Chinook salmon too) would continue to trickle into the Delta in low numbers under these low flow conditions prior to the main migration movement. This would place up to 5 percent of early migrants at risk of entrainment or having their migratory routes altered as discussed previously for export impacts in this document. This would potentially decrease the diversity of the life history strategies of the Chinook salmon and steelhead populations by not protecting these early emigrants to the Delta, and exposing them to high export conditions with more negative OMR flows.

2.5.5.8.4.2 End of OMR Flow Management

Reclamation and DWR proposed to end OMR flow management actions on June 30 at the latest, or when both of the following conditions are met, whichever is earlier:

- For Delta smelt protection, the condition for ending OMR flow management is when the mean water temperature in CCF reaches 25°C (77°F) for 3 consecutive days.
- For listed salmonid protections, the conditions for ending OMR flow management is when 95 percent of the listed population has migrated past Chipps Island as determined by the Delta monitoring work group, or, the daily average water temperature at Mossdale has exceeded 72°F (22.2°C) for 7 days during June. The water temperature days in June do not need to be consecutive.

In most years, the conditions for Delta smelt are likely to be the limiting factor, as water temperatures of 25°C (77°F) for 3 consecutive days in CCF typically occurs after water temperatures at Mossdale exceed 72°F and both conditions must be met to end OMR flow management. The criteria requiring 95 percent of a given listed salmonid population to have migrated past Chipps Island before ending the OMR flow management actions will typically be driven by the distribution of CV spring-run Chinook salmon, based on Chipps Island monitoring. Typically, at least 95 percent of winter-run Chinook salmon and CV spring-run Chinook salmon have left the Delta prior to the beginning of June (Figure 2.5.5-19 and Figure 2.5.5-20). On average, the date of all winter-run Chinook salmon passing Chipps Island is April 28. The average date for 95 percent of the annual CV spring-run Chinook salmon brood year passing Chipps Island is May 8. For CCV steelhead, the average date by which 95 percent of the annual population has past Chipps Island is April 28, based on information from the SacPas website

(www.cbr.washington.edu/sacramento/). These dates are derived from retrospective analysis of the Chipps Island trawl data. While the current DOSS working group does make estimates of CV spring-run Chinook salmon distribution in the Delta, DOSS does note that those estimates are very uncertain once hatchery fall-run Chinook salmon are present in the system. Since most monitoring locations use length-at-date criteria to assign fish to run, and many of the unmarked 75 percent of the hatchery releases may fall into the CV spring-run Chinook salmon size class, it becomes more difficult to interpret the data on spring-run-sized fish. Since the current DOSS working group does not make any assessments of CCV steelhead distribution in the Delta, there is no existing information to use for how the group will assess late season steelhead distribution and whether it will track with the data in the website in real time.

The current management of OMR flows, with the cap on OMR flows not being more negative than -5,000 cfs during the salmonid migratory period, continues through June 15, with an offramp if there are 7 consecutive days of water temperatures exceeding 72°F (22°C) after June 1). This restriction on OMR flows was designed in part to protect late emigrating salmonids, particularly CCV steelhead from the San Joaquin River basin that typically migrate out of the system in April and May. The Chipps Island trawl data for CCV steelhead are heavily biased by the much larger population of CCV steelhead originating in the Sacramento River basin. Thus, the earlier date of April 28 for the time when 95 percent of the current year's juvenile CCV steelhead population having passed Chipps Island is skewed by the differences in the Sacramento and San Joaquin river basins CCV steelhead populations. The date reflects the dominate size of the Sacramento River basin population and its migratory patterns, and not necessarily the migratory behavior of the smaller San Joaquin River basin steelhead population.

Therefore, the proposed end of OMR management poses a greater risk to San Joaquin River CCV steelhead than the current management of OMR flows under the COS if CCF temperatures are not controlling. There is the potential to end OMR flow management prior to the completion of the San Joaquin River basin's steelhead outmigration, and place these fish at greater risk of entrainment at the export facilities or alterations of their migratory routing, leading to increased transit times and distance, resulting in reduced survival.

2.5.5.8.4.3 Additional Real-time OMR Management Actions

2.5.5.8.4.3.1 Turbidity Bridge Avoidance

Reclamation and DWR propose to implement PA components designed to avoid creating a turbidity bridge between the main stem of the San Joaquin River to the north, and the export facilities to the south to protect adult Delta smelt that may be present in the main stem of the San Joaquin River from moving southwards towards the export facilities. This PA component will be implemented after the completion of the integrated early winter pulse protection action (First Flush) or by February 1, whichever comes first. Exports will be managed to maintain a daily turbidity average at the Old River at Bacon Island (OBI) monitoring site at a level less than 12 NTU. If turbidity does not exceed 12 NTU, there is no explicit OMR limits for protecting Delta smelt. If daily turbidity levels exceed 12 NTU, the 3-day average OMR index values will not be more negative than -2,000 cfs until the 3-day average turbidity at OBI falls below the 12 NTU threshold. This PA component will be implemented from February 1 to March 31, even if the first flush action has not occurred earlier in the year. This PA component will not be required on or after April 1.

This PA component has the potential to be beneficial to listed salmonids or sDPS green sturgeon if the turbidity criteria are exceeded and the OMR flows are capped at being no more negative than -2,000 cfs during the turbidity bridge event. However, if the turbidity criteria for protecting Delta smelt has not been met and if the criteria for protecting salmonids during this period has not occurred (i.e., more than 5 percent of any listed salmonid population is in the Delta after January 1), then any listed salmonids or sDPS green sturgeon present in the Delta would be vulnerable to the effects of the elevated exports allowed under this proposal, since there are no explicit OMR limits required for protecting Delta smelt. However, it would be unlikely that there would not be at least one population of listed salmonids that would have at least 5 percent of their population in the Delta at this time (likely winter-run Chinook salmon) and, thus, there would already be the requirement that OMR flows be no more negative than -5,000 cfs to protect listed salmonids from the effects of high exports.

2.5.5.8.4.3.2 Larval and Juvenile Delta Smelt Protections

Reclamation and DWR propose to protect larval and juvenile Delta smelt be changing operations when the flows in the western Delta, as measured by Q-West, are negative, and real-time Delta smelt monitoring indicates that Delta smelt larvae and juveniles are within the entrainment zone of the export pumps. The PA component will depend on hydrodynamic modelling that will estimate the percentage of the larval and juvenile smelt population that are at risk of entrainment, and operate to avoid a loss of no greater than 10 percent of the population. The description of the PA component does not explain what actions will be taken, or to what degree exports will be modified, so our assessment of impacts on listed salmonids is qualitative.

Reductions in export pumping are typically beneficial to listed salmonids and sDPS green sturgeon and reduce the risk of entrainment and the alterations in routing and transit times associated with the effects of exports on local hydrodynamic conditions. During the period that actions would be taken to protect larval and juvenile Delta smelt (mid-March through June), actions to protect listed salmonids would most likely already be restricting the OMR flows to no more negative than -5,000 cfs.

2.5.5.8.4.3.3 Natural CCV Steelhead Protection

Reclamation and DWR propose under the PA (April 30, 2019; Appendix A2) to protect CCV steelhead by operating to an OMR flow of -2,500 cfs for 5 days whenever more than 5 percent of the annual population of CCV steelhead is determined to be in the Delta by the Delta specific working group and that the daily cumulative loss of natural (unclipped) steelhead at the CVP and SWP fish salvage facilities exceeds 10 fish per a thousand acre feet of water exported (10 fish/TAF. Reclamation and DWR intend for this PA component to protect San Joaquin River basin steelhead, but acknowledge that it is not feasible to discern which basin the observed CCV steelhead in salvage are coming from. This PA component will end on May 31 of each season.

Currently there is no assessment of when 5 percent of the population has entered the Delta, and no assessment of the size of the steelhead cohort each year to base it on. It is unclear how any new Delta specific working group will do this assessment due to the difficulty of monitoring for steelhead and their ability to avoid most monitoring gear. Furthermore, most CCV steelhead salvaged at the CVP and SWP fish salvage facilities are believed to be from the Sacramento River basin due to the greater population size originating in that basin. The San Joaquin River

basin is believed to have a substantially smaller population size that would be overwhelmed by the signal generated by Sacramento River basin fish in salvage. The disparity in population sizes is just one factor making detection, and therefore protection of San Joaquin River basin fish difficult with this PA component. Another factor is the apparent differences in out migration timing. Sacramento River basin fish tend to emigrate earlier in the season than do San Joaquin River basin fish. Most Sacramento River basin CCV steelhead emigrate earlier in the season as indicated by the Sacramento trawl data (February and March, Figure 2.5.5-22) compared to the April and May period for the San Joaquin River basin population, and are likely the majority of CCV steelhead that are salvaged by the end of April (90 percent of salvage by May 1; Table 2.5.5-19). It is unlikely that the size of the San Joaquin River basin CCV steelhead population would be sufficient to trigger the 10 steelhead/TAF threshold that Reclamation and DWR are proposing. NMFS expects that in most instances when the loss density of natural CCV steelhead has exceeded the 10 fish/TAF threshold that these fish belonged to the Sacramento River basin population and not to the San Joaquin River basin population. Currently export reductions are taken at two different levels of steelhead loss density; 8 fish/TAF and 12 fish/TAF. If the first level is exceeded, OMR is held at no more negative than -3,500 cfs for a minimum of 5 days. If the second level is exceeded, than OMR is held at no more negative than -2,500 cfs for a minimum of 5 days. Furthermore, NMFS assessed the frequency of steelhead loss density trigger exceedances since water year 2010 (the year that the RPA actions from the NMFS2009 Opinon were first implemented) and found that incorporation of the proposed loss density trigger would reduce the implementation of OMR protective actions, based on steelhead loss density triggers, by 26 percent over all of the years in the period (2010-2018) and 46 percent in the years in which loss density triggers were actually exceeded (Table 2.5.5-23).

In contrast, OMR flows in April and May are approximately 4,000 cfs more positive under the COS than the PA in wetter years. In drier years (below normal and dry water year types) the differences between the PA and COS were less, but were still approximately 1,500 cfs more positive under the COS conditions as compared to the PA conditions. In critical water year types, the COS was modelled to be 600-800 cfs more positive than the PA conditions. Seldom during the April and May period are modelled OMR flows predicted to be more positive/less negative under the PA than under the COS conditions, and positive OMR flow values occur in April and May less frequently under the PA (<10 percent of years) compared to the COS (approximately 50 percent of years). During June, the PA is modelled as being more negative by 1,000 to 1,600 cfs in drier water year types (below normal, dry, and critical). Therefore, The COS is more protective of San Joaquin River basin CCV steelhead due to lower exports and more positive OMR flows than the proposed CCV steelhead loss density trigger. Under the PA, not only are OMR flows in April and May considerably more negative, but reductions in OMR flows (typically linked to reductions in exports) due to CCV steelhead loss density trigger exceedances will be less frequent.

Thus, the loss density trigger proposed by Reclamation and DWR is considerably less protective of CCV steelhead in general and particularly for the populations originating in the San Joaquin River basin. The triggers will be dominated by CCV steelhead from the Sacramento River basin and typically occur earlier in the season when these fish are present in the Delta system. The higher threshold for the loss density trigger means that the implementation of the OMR protective actions will only occur about half as frequently (54 percent) as compared to the current protective actions implemented in the COS conditions. A final exacerbation of the risk to

San Joaquin River CCV steelhead is the proposed elimination of the installation of the HOR barrier in the spring. This allows a greater opportunity for CCV steelhead from the San Joaquin River basin to migrate downstream through the Old River route and be exposed to the agricultural barriers as well as the export facilities with their associated reductions of survival, typically associated with migratory delays and increased predator exposure. Since it is unlikely that any reductions in exports will occur due to the proposed loss density trigger for CCV steelhead, exports are likely to continue at a rate that manages to an OMR of no more negative than -5,000 cfs during the spring. It is unlikely that at the export rates typical of this OMR level, that any fish arriving at the export facilities via Old River will escape the influence of the exports, and will be entrained into the fish salvage facilities. Its survival is then linked to the efficiency of the fish salvage operations and the predator field in front of the fish salvage facilities.

2.5.5.8.4.3.4 Salvage or Loss Thresholds

Reclamation and DWR propose under the PA (April 30, 2019; Appendix A2) to set annual cumulative loss or salvage thresholds to modify export operations rather than the current real time actions under the COS related to the NMFS 2009 Opinion RPA actions (National Marine Fisheries Service 2009b). The PA component sets the winter-run Chinook salmon threshold as equal to loss of 1 percent of the annual winter-run JPE for unclipped (natural) fish (genetically confirmed) or 2 percent of the JPE if length-at-date (LAD) identification is used. For unclipped CV spring-run Chinook salmon, a threshold of 1 percent loss of an annual spring-run JPE (or a loss threshold of 0.5 percent of the yearling CV spring-run Chinook salmon surrogate releases -late fall-run Chinook salmon from Coleman National Fish Hatchery) is proposed. NMFS assumes that the proposal would use the current methodology for calculating salvage and loss, based on expansion of observed salvaged fish and using the current loss multipliers. A threshold of 3,000 unclipped juvenile CCV steelhead in salvage is proposed for the PA. For green sturgeon, an annual salvage threshold of 100 fish is proposed. Reclamation and DWR intend to operate to -5000 cfs OMR flows until the annual cumulative loss or salvage reaches 50 percent of any of the threshold limits for a given species, at which point it will reduce exports and manage to an OMR limit of no more than -3.500 cfs on a 14-day moving average. If cumulative annual loss or salvage exceeds 75 percent of any annual threshold limit for a given species, then exports will be reduced to achieve an OMR flow of no more negative than -2,500 cfs on a 14-day moving average.

There are several factors which make this proposal difficult or unworkable. First, there is no CV spring-run Chinook salmon JPE currently calculated that could serve as the basis for the proposed limit, so presumably the threshold based on the yearling CV spring-run Chinook salmon surrogate releases would be implemented until a CV spring-run Chinook salmon JPE has been developed that would meet the objectives of this proposal. Secondly, based on historical salvage and loss data from the SWP and CVP facilities, it is unlikely that the 50 percent and 75 percent triggers would ever be exceeded. For unclipped winter-run Chinook salmon, the proposed 50 percent exceedance threshold (1 percent of JPE using LAD criteria) occurred six times since 1992, but only twice since the implementation of the COS starting with brood year 2009. These most recent events occurred in 2 years when the JPE was very low compared to other years (Table 2.5.5-25). There are no proposed loss threshold triggers for hatchery produced winter-run Chinook salmon. This leaves hatchery winter-run Chinook salmon vulnerable to

excessive entrainment. There is no CV spring-run Chinook salmon JPE, as previously mentioned, so there is no historical reference of proportional take to guide the impacts of the implementation of the proposed limit. In regards to the proposed limits for unclipped CCV steelhead, the historical record for unclipped steelhead since 1998 when all hatchery-produced CCV steelhead began to be adipose fin-clipped, the annual salvage of unclipped CCV steelhead exceeded 1,500 fish seven times. However since brood year 2009 when the COS was implemented, the trigger threshold has not been exceeded (Table 2.5.5-37). Since 2000, the annual salvage of sDPS green sturgeon has been less than 100 fish in any given year except for 2006, when 363 green sturgeon were salvaged. In recent years since 2010, only twice have sDPS green sturgeon been salvaged, and both times it was for a total of 4 fish annually, substantially below the 50 percent threshold of 50 fish required to initiate any export reductions to manage OMR flows.

Based on the above information, it is unlikely that the thresholds proposed by Reclamation and DWR will be exceeded, except on rare occasion. Thus, reductions in exports and changes to make OMR more positive are unlikely to occur and the OMR flows will stay at -5000 cfs for the entire period of implementation of OMR flow management (January 1 through late spring). This is considerably less protective than the current COS conditions which provide substantial export reductions in the April and May periods to protect San Joaquin River basin CCV steelhead. Furthermore, the proposed OMR flow management actions do not include real-time reductions based on daily trigger thresholds in the NMFS 2009 Opinion for RPA Action IV.2.3 (National Marine Fisheries Service 2009b). This places an additional risk on listed fish populations that are already experiencing difficult conditions in the Delta and have low overall population viability.

2.5.5.8.4.4 Storm-Related OMR Flexibility

Reclamation and DWR are also proposing to incorporate storm-related flexibility in OMR flow management by proposing combined exports to increase up to potentially full capacity (14,900 cfs) to capture any excess water in the Delta system that is available through storm-related increases in river inflows and export that water south of the Delta. The full description of the PA component is provided in Section 2.5.5.8.2 "OMR Flow Management." Storm-related increases in exports will not be allowed if any of the previous additional real-time OMR restrictions already discussed are triggered, and in that case, Reclamation would operate in accordance with those additional real-time OMR restrictions and would not cause OMR to be more negative for capturing peak flows from storm-related events.

The PA component also includes measures to off ramp from the storm flex exports if natural winter-run Chinook salmon are entrained and their calculated loss exceeds the percentages of cumulative loss thresholds tied to the annual JPE provided in Section 2.5.5.8.2. These percentages increase with the progression into the winter-run Chinook salmon migratory season and extend through the end of the OMR flow management period.

The Salmonid Scoping Team (Management Question #3 in Volume 2, 2017b) summarized the conceptual model for export-related effects on salmonids as follows:

"Export effects that incrementally increase the routing of juvenile salmonids (either from the Sacramento River or from the San Joaquin River) into the Interior Delta will incrementally reduce overall survival...In addition to the predicted effects of export on routing, the conceptual model predicts that OMR reverse flow management will decrease mortality by increasing the probability that juveniles that enter the South Delta (San Joaquin River mainstem and channels to the south and west of the San Joaquin River mainstem) will successfully migrate out of the South Delta to Chipps Island. Mechanisms by which this might occur include: 1) reducing entrainment at the export facilities...; 2) reducing confusing navigational cues caused by OMR reverse flow; and 3) increasing the duration and magnitude of ebb tide flows and velocities, relative to flood tides, which is expected to reduce the residence time of juveniles in the South Delta and, therefore, reduce exposure time to agents of mortality."

Key conclusions in the SST report were:

- For junctions on both the Sacramento River and San Joaquin River, "...a -5,000 cfs OMR reverse flow limit provides protection compared to more negative OMR reverse flow levels that would exert a larger influence on flow routing at distributary junctions and, thus, on juvenile routing and survival." However, the SST "did not conclude at what precise level of OMR flow more negative than -5,000 cfs exports would begin to affect distributary flows, juvenile routing, and survival", and also noted some technical disagreement on this point.
- Within the interior channels of the South Delta, "...the -5,000 cfs OMR flow is predicted to be less effective at preventing or minimizing export effects on juvenile routing at junctions and residence times within the interior channels of the South Delta than in the mainstems of the Sacramento River and San Joaquin River...because the export-driven influence on hydrodynamic conditions at a given OMR flow level increase with proximity to the export facilities.
- The SST noted that there is "inadequate empirical evidence from fish tracking studies to
 more precisely evaluate junction-specific relationship between distributary flow changes
 and changes in fish routing and survival. As a results there is uncertainty in relating
 specific OMR reverse flow thresholds to overall through-Delta survival.
- The SST concluded that "...route selection is generally proportional to the flow split at channel junctions, and the effect of exports on route selection is strongest at the junction leading directly to the export facilities (i.e., Head of Old River)."

We can evaluate some of the conceptual model mechanisms described above based on modeling provided in the ROC on LTO BA. The salvage density modeling shows that salvage and associated loss increases with exports during months when listed salmonids are present in the Delta. Therefore, if fish are present in the vicinity of the export facilities in the south Delta during a time that storm flex export operations are implemented, NMFS concludes there will be an increase in the number of fish entrained into the salvage facilities above that which would have been seen with no increases in exports. Furthermore, since listed salmonids tend to start migrating downstream in response to elevated flows in the Sacramento River basin and San Joaquin River basin waterways, there is a high probability that more fish will be present in the Delta exactly when the CVP and SWP increase their exports. Besides the fish entering the Delta on the elevated storm flows, listed salmonids (especially winter-run Chinook salmon) may already be present in the Delta due to migration earlier in the year. This overlap in fish presence and the potential for combined exports to reach 14,900 cfs can result in increased entrainment

risk as a result of the potentially very negative OMR flows. Reclamation has committed to a risk assessment before implementing a storm flex export operation which could limit risks. The Salmonid Scoping Team (2017a) concluded that "...route selection is generally proportional to the flow split at channel junctions, and the effect of exports on route selection is strongest at the junction leading directly to the export facilities (i.e., Head of Old River)." Any fish that originates in the San Joaquin River basin will be at a high risk of entrainment due to the routing of fish through Old River from the HOR. The fish that stay within the main stem San Joaquin River channel at the Head of Old River may enter the interior Delta at other junctions and be exposed to the increased foot print of the altered hydrodynamics created by the high level of exports in the channels leading to the pumps. Triggers based on loss density for unclipped steelhead are less likely to happen under the high export condition as greater volumes of water are present to be diverted, compared to the number of fish present to be entrained in the surrounding waterways.

The hydraulic conditions created by the high export rates have a high probability of creating more adverse conditions in the south Delta waterways than are currently observed for migrating fish. The severity will depend on which basin has the high storm flows and to what extent the exports are increased. Assuming the worst case scenario, combined exports of 14,900 cfs, with flows originating only in the Sacramento River basin, the footprint of the export effects will encompass much of the south and central Delta up to and including the main stem San Joaquin River downstream to at least Jersey Point. If the storms are present only in the Sacramento River basin and river flows are increased only for that basin, then elevated exports will exaggerate the effects of OMR as water is predominately coming from the north across the Delta to supply the high exports. Low flows in the San Joaquin River basin at the same time would exacerbate this condition, as they would not offset the source of export water being diverted by the pumps. Conversely, if storms are centered over the San Joaquin River basin and high delta inflows are confined to the main stem of the San Joaquin River, the high export rates will pull in mostly water from this source. Flow through Old River via the HOR will offset the effects of exports on OMR flows to some extent, depending on the magnitude of combined exports, and the volume of flow coming through the HOR. Because there is less unregulated flow in the San Joaquin River compared to the Sacramento River, "storm" events that trigger an OMR storm flex are more likely to be dominated by Sacramento River flow.

2.5.5.8.5 South Delta Export Facilities

2.5.5.8.5.1 Minimum Export Rate

Reclamation and DWR propose to have a minimum combined export rate of 1,500 cfs for human health and safety. This level of exports would meet the minimum level of water supplies obligated to senior water rights holders and minimum deliveries to wildlife refuges. This low level of exports is not expected to substantially impact OMR flows or alter hydrodynamics in the South Delta except under the very lowest of river inflow conditions. At an export level of 1,500 cfs however, the efficiency of the louvers that make up the primary fish screens at both the SWP and CVP decreases, and more fish that encounter the louvers are lost to the system through the louvers, or fail to enter the bypasses that lead to the secondary screens and the holding tanks. This risk is reduced by the reduction in the effects of the export pumping in the near-field and far-field areas of the south Delta adjacent to the location of the CVP and SWP. Reduced exports

of 1,500 cfs are expected to produce more positive OMR flows and reduce the extent of the export's zone of influence in channels leading towards the pumps.

2.5.5.8.5.2 Tracy Fish Facility Improvements

2.5.5.8.5.2.1 Predator Removal (CO₂ injection)

A number of conservation measures are proposed to improve salvage efficiency at the Tracy Fish Collection Facility (TFCF), including installing a carbon dioxide (CO₂) injection device to allow remote controlled anesthetization of predators in the secondary channels of the TFCF by elevating the dissolved CO₂ concentration in the secondary channels. These PA components could potentially benefit juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon through greater salvage efficiency and reduced mortality related to predation.

2.5.5.8.5.2.1.1 Deconstruction of the Action

Reclamation proposes to construct a CO₂ injection device within the secondary channel of the TFCF. The device will diffuse CO₂ gas into the water column of water moving into the secondary channel when removal of predators is warranted. The device has not been explicitly described in the BA, but is likely to consist of a manifold with diffuser pipes through which CO₂ gas is diffused into the water column of the secondary channel. Construction of such a device will require that the secondary channels be dewatered for periods of time to install the infrastructure. Construction of the device will occur during the August through October in-water construction period. Operations of the device will, at a minimum, occur during the period in which listed salmonids and sDPS green sturgeon are present, and may occur year-round.

2.5.5.8.5.2.1.2 Exposure of Listed Salmonids to Construction

During construction of the CO2 injection system, winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead are not expected to be exposed to the effects of construction, based on the timing of in-water construction (August–October) and the typical seasonal occurrence and salvage timing in the Delta of listed salmonids. Although the construction window avoids the majority of the juvenile salmonid migration period in the Delta, a few migrating juvenile salmonids could still occur during the in-water work window. To minimize or avoid adverse effects to these few fish due to construction activities, Reclamation proposes to minimize risk by incorporating the appropriate avoidance and minimization measures (AMMs) (Reclamation [2019], Appendix E, Avoidance and Minimization Measures) into the construction protocol.

2.5.5.8.5.2.1.3 Exposure of sDPS Green Sturgeon to Construction

Juvenile sDPS green sturgeon can occur in the Delta year-round and, therefore, have the potential to be exposed to the effects of construction of the CO₂ injection device proposed for the TFCF improvements. If construction impacts the efficiency of green sturgeon salvage, there could be a minor effect to a small number of individual fish, although risk would be minimized through the incorporation of appropriate AMMs. As with other proposed construction in the Delta under the PA, the timing of early out-migrating adult sDPS green sturgeon occurrence in the Delta could overlap with CO₂ injection device construction as part of TFCF improvements.

Application of AMMs and the small scale of the in-water construction would minimize the potential for any effects to individual adult sDPS green sturgeon.

2.5.5.8.5.2.1.4 Risk to Listed Salmonids during Construction

The risk to listed salmonids should be minimal as the construction of the CO₂ injector occurs during the in-water work window of August through October when listed salmonids are least likely to be present. Incorporation of the AMMs will further reduce the potential of any risk to listed salmonids. Furthermore, installation of the injector will occur in the dewatered secondary channel. The secondary is typically dewatered to work on the secondary travelling screens or to remove predators, and flushes all fish in the secondary channel into the holding tanks where they are held until release. During any dewatering of the secondary channel, salvage operations are suspended, and any listed salmonid present may pass through the primary louvers into the intake channel leading to the export pumps where it is lost to the system.

2.5.5.8.5.2.1.5 Risk to sDPS Green Sturgeon during Construction

The risk to sDPS green sturgeon is considered to be low. Although green sturgeon are present year-round in the Delta, the incorporation of the AMMs will further reduce the risk of exposure to construction effects. As described for the listed salmonids, the secondary channel will be dewatered, and any sDPS green sturgeon present will be flushed into one of the holding tanks for future release. There is the potential that during the period that the secondary channel is dewatered and salvage operations are halted, that any individual sDPS green sturgeon present in the primary channel may pass through the primary louvers into the intake channel and be lost to the system. This is considered unlikely as the probability of any sDPS green sturgeon being present in the primary at the time of dewatering is low, given their rarity in salvage at any time.

2.5.5.8.5.2.1.6 Exposure of Listed Salmonids and sDPS Green Sturgeon during Operations

The CO₂ injection system is intended to be used to remove predators during the periods of the year when listed salmonids are present in salvage. Therefore, winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead have the potential to be present during the use of the injector system during predator removals. Any listed salmonid present in the secondary channel at the time of the predator removal will be exposed to the effects of the elevated dissolved CO₂ concentrations in the water of the secondary channels.

2.5.5.8.5.2.1.7 Risk to Listed Salmonids and sDPS Green Sturgeon during Operations

Once installed, Reclamation proposes to use the CO₂ injection device to clear predators from the secondary channel on a regular basis. Reducing the predator density within the secondary channels will enhance survival through the TFCF by reducing predation on listed salmonids and sDPS green sturgeon passing through the secondary channel to the holding tanks. Predator removal targets those predators that are present in the secondary channel and bypass system, many of which are resident or semi-resident within the system. Removal of these predators reduces the standing population of predators within the TFCF. During a predator clean out of the secondary channel, water is directed into the holding tank used for salvage counts while the CO₂ is injected into the secondary channel. Predators that are anesthetized by the CO₂ are drawn into the holding tanks by the water flow where they can be removed from the system during regular salvage counts and potentially relocated to waters outside of the Delta (e.g., Delta Mendota

Canal, Bethany Reservoir). Listed salmonids may be exposed to the effects of the increased dissolved CO₂ (hypercapnia) during predator removals and also become anesthetized. A proportion of these fish, due to their smaller size, may die due to the effects of the increased CO₂ levels in their blood stream. However, the reduction in predation loss within the TFCF resulting in greater salvage efficiency and higher overall survival will offset the number of fish lost through the exposure to the elevated CO₂ concentrations in the secondary channels during a predator clean out.

2.5.5.8.5.2.2 Tracy Fish Collection Facility Release Sites Improvements

In addition to incorporating the CO₂ injection system into the secondary channels to reduce predator density, Reclamation is also proposing to modify its procedure for releasing salvaged fish back into the Delta. Currently, Reclamation manages two release sites in the Delta, one on the Sacramento River near Horseshoe Bend, and the other on the San Joaquin River immediately upstream of the Antioch Bridge. Reclamation is proposing to add additional release sites in the western Delta outside the influence of the export operations. Additional release sites, coupled with a rotating release schedule between sites, is believed to reduce the potential for predators to habituate to a given release site as a source of food. In theory, if the number of release sites is low, and the release of salvaged fish occurs frequently (up to several times a week per site) then predators will associate the release locations and the release site pipe as a source of food in the form of released fish from the salvage operations exiting from the end of the pipe, including listed salmonids. Although some loss will occur due to predation at the additional sites, the current belief is that the cumulative loss due to predation from all release sites should be reduced due to lower predator density at each release site. However, the lack of information regarding the locations of the alternative release sites, and the intended construction actions and their impacts do not permit a complete effects analysis to be done for this PA component, thus it will be considered as a programmatic consultation.

2.5.5.8.5.2.3 Tracy Fish Collection Facility Infrastructure Improvements

Reclamation proposes to improve the infrastructure of the TFCF to reduce the loss of entrained fish by: (1) incorporating additional fish exclusion barrier technology into the primary fish removal barriers, (2) incorporating additional debris removal systems at each trash removal barrier, screen, and fish barrier, (3) Constructing additional channels to distribute the fish collection and debris removal among redundant paths through the facility, (4) Construct additional fish handling systems and holding tanks to improve system reliability; and (5) Incorporate remote operation into the design and construction of the facility. These physical infrastructure improvements are likely to enhance the overall efficiency of the salvage facility while ultimately reducing the level of loss of entrained fish. In particular, the construction of additional channels to distribute the fish collection and debris removal among several redundant pathways has the potential to reduce or eliminate the issue of open louver bays during the cleaning process, as is the case at the SDFPF with its multiple primary inlet channels that can be operated independently from each other.

However, the lack of details and specificity of design and construction schedule do not allow for the analysis of project effects for this PA component. The scope of this PA component will likely require several years to complete infrastructure improvements and testing, and may require numerous construction actions, all of which have not been described. Therefore, this PA component will be considered as a programmatic consultation.

2.5.5.8.5.3 Skinner Delta Fish Protection Facility Improvements

The PA components associated with Skinner Delta Fish Protection Facility improvements involve predator control efforts and are intended to reduce predation on listed fish species following their entrainment into CCF. This improvement could benefit juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon entrained into CCF by reducing predation and pre-screen loss (mortality).

DWR proposes to continue the implementation of projects to reduce mortality of listed salmonids and sDPS green sturgeon at the SWP facilities. These projects include studies to reduce the predation of listed fish in the CCF and operational changes that have the potential to benefit listed fish and reduce mortality. Specifically, DWR propose to continue studies regarding: (1) the electro-fishing of predatory fish and their relocation from CCF (the Predator Reduction Electrofishing Study [PRES]); (2) controlling aquatic weeds that provide habitat for predatory fish; (3) a predatory fish relocation study (PFRS) that uses commercial fishing techniques to capture predators and relocating them away from CCF; and (4) developing operational changes (i.e., preferential pumping through the Federal Jones Pumping Plant) that provide additional protection to listed fish when they are present.

2.5.5.8.5.3.1 Deconstruct the Action - Predator Reduction Electrofishing Study (PRES)

DWR has already completed a 3-year study of the PRES, but is proposing to continue the study for an additional 2 years (California Department of Water Resources 2018a). The PRES study will take place within CCF and will collect and relocate predatory fish in order to study the effects of the predator removal on survival of listed salmonids. The PRES will use three electrofishing boats that will be fished concurrently within CCF to capture target predatory fish species (striped bass [Morone saxatilis], largemouth bass [Micropterus salmoides], spotted bass [M. punctulatus], channel catfish [Ictalurus punctatus], white catfish [Ameiurus. catus], black bullhead [A. melas], and brown bullhead [A. nebulosus]). These species (or other predatory species collected but not listed) will be re-located to Bethany Reservoir. The three electrofishing boats will make systematic sweeps through CCF. The proposed fish collections will occur 4 days a week from January to June, as conditions allow. No collection will occur once temperatures in the CCF exceed ~21°C. This schedule may be altered for safety reasons (weather or boating conditions), staffing, CCF hunting events or environmental conditions (presence of aquatic vegetation), or other unforeseen variables. If listed fish are incidentally collected during the electrofishing, crews will recover them, identify them, take and archive genetic tissue samples as permitted, and release the species back into CCF.

2.5.5.8.5.3.1.1 Exposure of Listed Fish to the PRES

Listed fish are expected to be present within the CCF during the implementation of the PRES. From January to June, winter-run and CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be present and potentially exposed to the effects of the electrofishing operations within the confines of CCF.

2.5.5.8.5.3.1.2 Response of Listed Salmonids to the PRES

Listed salmonids that are present in the vicinity of the electrofishing boats will be exposed to the electrical current within the water column when the boats are actively fishing. Since the boats are targeting larger fish species that would be capable of predating on juvenile Chinook salmon or CCV steelhead, less voltage is required to stun these fish. The greater length of the predatory fish creates a greater voltage gradient along the length of the fish, and thus less voltage is needed to anesthetize the fish in the electric field. However, larger fish such as sDPS green sturgeon, adult salmonids, or even larger CCV steelhead smolts may be susceptible to the electric field and become stunned. As evidence of this risk, the cumulative incidental take of Chinook salmon and steelhead from the previous 3 years of study is 152 Chinook salmon and 50 steelhead observed moving into the vicinity of the electrofishing boats in response to the electric field. The protocol for the electrofishing crews is to stop fishing if they observe salmonids entering the electric field of the boats, and move to another location. All of the salmonids observed during the first 3 years of study immediately recovered when the electrofishing equipment was turned off.

2.5.5.8.5.3.1.3 Response of sDPS Green Sturgeon to the PRES

As discussed above, larger fish are more susceptible to the effects of electrofishing due to their greater length and the larger voltage gradient across their body. During the previous 3 years of the PRES, no sDPS green sturgeon were reported in the incidental catch of listed fish. This could be due to several factors. sDPS green sturgeon are benthic oriented and prefer deeper waters to hold in. It is possible that the electric field used in the PRES did not reach deep enough into the water column to affect sDPS green sturgeon, or that the habitats that were sampled did not contain any sDPS green sturgeon to begin with. However, if larger sDPS green sturgeon were exposed to the electric field, there is the potential for notochord injury due to the reflexive muscle contractions caused by the electric field. The larger the fish, or the greater the voltage gradient, the more violent and forceful the contractions can be, and the higher the probability of injury (McMichael et al. 1998, Holliman and Reynolds 2002).

2.5.5.8.5.3.1.4 Risk to Listed Salmonids

There is an inherent risk to listed salmonids associated with the proposed use of electrofishing in the PRES. However, due to the targeting of larger predatory fish, most of the listed salmonids in the CCF will be much smaller than the size of the predators, and, therefore, the effects of the electric field generated by the electrofishing equipment should not physically harm them. As stated above, the protocols used by the electrofishing teams require them to turn off the equipment if they observe any salmonids being drawn to the electric field. This prevents the fish from becoming incapacitated, and vulnerable to predation, either by avian predators or by predatory fish.

2.5.5.8.5.3.1.5 Risk to sDPS Green Sturgeon

Like listed salmonids, there is an inherent risk associated with the use of electrofishing in the PRES. Due to the larger size of sDPS green sturgeon, the risk of injury is greater than to the smaller salmonids. Water depth and protocols that require the turning off of the equipment if listed fish are observed will reduce the risk to sDPS green sturgeon.

2.5.5.8.5.3.2 Deconstruct the Action - Predator Fish Relocation Study (PFRS)

The PFRS proposes to use commercial fishing techniques to capture predatory fish within the CCF. These techniques will include both passive and active fishing methods. The methods include beach seines, purse seines, fyke traps, hoop nets, and trawls. The size of the net mesh will be no smaller than 2 inches stretched. Each fish collection method is expected to sample different habitats in CCF and target different predatory species. The specific habitats sampled by collection methods include the Scour Hole, deep habitat (> 60 ft. deep) immediately downstream of the Radial Gates, the Intake Channel leading to the SDFPF, shoreline habitat, and shallow mudflat areas (< 6 ft. deep) throughout CCF. The details of each method and the frequency of sampling are described in a separate BA developed for this study (California Department of Water Resources 2018a). The PFRS was proposed as an additional study to be implemented by DWR to reduce predation in CCF during the ROC on LTO consultation, replacing the fishing incentive program originally proposed. Proposed fish collection will take place Monday through Thursday each week from October through June, as conditions allow. No collection will occur once temperatures in the CCF exceed ~21°C. This may follow the same general schedule as PRES, but could be altered for safety reasons (weather or boating conditions), staffing, CCF hunting events or environmental conditions (presence of aquatic vegetation), or other unforeseen variables. Any predator fish collected will be transported to Bethany Reservoir and released. There is no access from Bethany Reservoir back into the Delta.

During fish collection, listed species including CV spring-run Chinook salmon, winter-run Chinook salmon, sDPS green sturgeon, and CCV steelhead could be captured. Each crew will identify and enumerate all ESA-listed fish species captured as incidental bycatch, take tissue samples and archive with CDFW, as appropriate, and release the species back into CCF.

2.5.5.8.5.3.2.1 Exposure of Listed Fish to the PFRS

Listed fish are expected to be present within the CCF during the implementation of the PFRS. From January to June, winter-run Chinook salmon and CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be present and potentially exposed to the effects of the fishing operations within the confines of CCF. From October through December, only sDPS green sturgeon are expected to be present.

2.5.5.8.5.3.2.2 Response of Listed Salmonids to the PFRS

Although most juvenile Chinook salmon should be small enough to escape through the mesh of the nets, some of the larger fish may become entangled when they try to swim through the net. When fish entangle themselves in the net, they risk damaging their sensitive gill structures or injuring their eyes. Furthermore, abrasions along the body may become infected. These injuries will reduce the fitness of the fish and may lead to death or predation in its weakened state. In addition, listed salmonids that are entrapped in the fyke, traps or hoop nets with predators may be predated upon if they cannot escape through the mesh. During each set of the nets, study personnel are on hand to monitor the nets. For beach seines, purse seines, and trawls, the duration of the net set is short and most listed fish should be recovered alive and released back into the waters of CCF. The fyke traps and hoop nets are fished overnight and the risk to fish increases due to the longer soak time. For all fishing techniques, there are protective fish handling and recovery protocols that are designed to minimize the stress of capture of any listed

salmonid. Listed fish are removed from the nets or traps first and processed. Fish will be allowed to recover in holding units and will only be released when they regain fully normal behavior and function.

2.5.5.8.5.3.2.3 Response of sDPS green sturgeon to the PFRS

Entanglement of sDPS green sturgeon in the mesh of the nets is likely due to their behavior of rolling in the nets when captured. As described above for listed salmonids, fish are immediately removed from the nets when the haul is completed and processed. The fish handling and recovery protocols are designed to minimize the stress of capture and fish are allowed to recover fully before being released back into the waters of CCF.

2.5.5.8.5.3.2.4 Risk to listed salmonids to the PFRS

The PFRS will be conducted during the period when juvenile listed salmonids are present in CCF and they will be vulnerable to capture by the different commercial fishing techniques employed. Capture in the beach seine, purse seine, or trawl should have a relatively low risk of mortality due to the short time of each fishing event and the proposed fish handling and recovery protocols. In contrast, the fyke trap and hoop nets pose a greater risk due to the longer soak times overnight. Captured salmonids will be exposed to predation in the traps if they cannot escape through the mesh, or may die or be eaten if they become ensnared in the mesh trying to escape.

2.5.5.8.5.3.2.5 Risk to sDPS green sturgeon to the PFRS

Some sDPS green sturgeon are likely to be present in CCF during the study and will be vulnerable to the fishing techniques employed. Like the listed salmonids, risk to sDPS green sturgeon is low for the beach seines, purse seines, and trawls due to the short time of the fishing events and the lower probability that they will be present in the areas available for beach seining or within the portion of the water column vulnerable to the purse seines or surface trawls. Benthic trawls that target deeper water are more likely to capture sDPS green sturgeon, but the short duration of the trawl will allow any captured sDPS green sturgeon to be quickly processed and released. Capture of sDPS green sturgeon in the fyke trap or hoop nets will result in longer periods of time in which the fish may be entangled in the nets before processing. However, based on other studies in the Delta, the overnight soak time should not create sufficient stress to result in death of the captured fish.

2.5.5.8.5.3.3 Deconstruct the Action - Aquatic Weed Control for Predator Habitat

DWR proposes to control aquatic weeds that provide habitat for predatory fish. Most of this weed control will be focused on specific areas and may only require spot removal or use of a mechanical harvester to remove the floating or shallow submerged aquatic vegetation. These actions will typically take place in the summer and will coincide with the larger aquatic weed control program in CCF.

2.5.5.8.5.3.3.1 Exposure of Listed Fish to Aquatic Weed Control for Predator Habitat

Listed salmonids are not expected to be present within the CCF during the implementation of the weed control program to reduce habitat for predatory fish during the summer, however sDPS green sturgeon may be present at this time. From January to June, winter-run and CV spring-run

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Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be present and potentially exposed to the effects of the reduced vegetation cover for predators.

2.5.5.8.5.3.3.2 Response of Listed Salmonids to Aquatic Weed Control for Predator Habitat

Listed salmonids should benefit from the removal of submerged and floating vegetation that serves as habitat for ambush predators. With less habitat to hide in, ambush predators will have to move away from the cleared areas, thus reducing the potential exposure of listed salmonids to ambush attacks in a greater area of CCF.

2.5.5.8.5.3.3 Response of sDPS Green Sturgeon to Aquatic Weed Control for Predator Habitat

There is likely little response to the cleared habitat from sDPS green sturgeon. sDPS green sturgeon are probably not as vulnerable to ambush predators as salmonids since they inhabit deeper portions of CCF and are likely to congregate in areas devoid of any vegetation (i.e., deep scour hole).

2.5.5.8.5.3.3.4 Risk to ESA-Listed Salmonids to Aquatic Weed Control for Predator Habitat

Since the action is likely to occur during the summer, no listed salmonids are expected to be present. Therefore the risk is considered to be minimal.

2.5.5.8.5.3.3.5 Risk to sDPS Green Sturgeon to Aquatic Weed Control for Predator Habitat

The risk to sDPS green sturgeon is minimal due to the area in which the sDPS green sturgeon are likely to be found. The areas in which aquatic weed control of floating and shallow submerged weeds is not the type of habitat that sDPS green sturgeon are likely to be found in.

2.5.5.8.5.3.4 Deconstruct the Action - Operational Changes when ESA-Listed Fish are Present

DWR proposes to shift exports from the SWP to the CVP under the new addendum to the COA provisions signed on December 12, 2018, when it would benefit listed fish species. An "Operational Changes Summary" document (DWR, March 1, 2019) from DWR indicates that in order to reduce pre-screen loss in CCF, the SWP will shift some of its "pumping at Banks Pumping Plant to the Central Valley Project at Jones Pumping Plant when listed species are present. The amount of shifted pumping under Stage 1 Joint Point of Diversion will be limited by the operational or available physical capacity at Jones Pumping Plant. Any SWP pumping greater than what can be shifted to the CVP would still be exported through CCF and Banks Pumping Plant. A minimum SWP pumping amount of approximately 300 cfs is required to support Byron-Bethany and South Bay Aqueduct water needs. This action could occur anytime between January 1 and June 15."

2.5.5.8.5.3.4.1 Exposure of ESA-Listed Fish to the Operational Changes when ESA-Listed Fish are Present

Listed salmonids are typically present in salvage from December through June of each year at the south Delta export facilities. The salvage of juvenile winter-run Chinook salmon typically occurs from December through March. Salvage of CV spring-run Chinook salmon may occur as early as December and January (yearling life history phase) and extends through May and early June for young-of-the-year juveniles. CCV steelhead may be salvaged in any month of the year, but primarily from December through June. The salvage of sDPS green sturgeon may occur during any month of the year based on their year-round presence in the Delta. Listed salmonids and sDPS green sturgeon will be present during the periods when this shift in exports is likely to occur. The shifting of exports is predicated on the presence of listed fish in salvage at the SWP, and the availability of capacity at the CVP.

2.5.5.8.5.3.4.2 Response of Listed Salmonids to the Operational Changes when ESA-Listed Fish are Present

This PA component is designed to reduce the number of listed salmonids lost through the SDFPF. However, shifting exports to the CVP may result in more fish being entrained into the TFCF, but the combined loss between the two facilities should be reduced, as the loss expansion for salvaged fish is less at the CVP than it is at the SWP. This difference is due to the much higher pre-screen loss associated with CCF that influences the magnitude of loss at the SWP.

2.5.5.8.5.3.4.3 Response of sDPS Green Sturgeon to the Operational Changes when ESA-Listed Fish are Present

sDPS green sturgeon should have a similar positive response to the shifting of exports to the CVP. Although the rate of loss for sDPS green sturgeon is unknown, lower entrainment into CCF would benefit sDPS green sturgeon by keeping them out of CCF where they can become trapped behind the radial gates.

2.5.5.8.5.3.4.4 Risk to ESA-Listed Salmonids to the Operational Changes when ESA-Listed Fish are Present

The risk of predation to listed salmonids is likely to be reduced by reducing entrainment into CCF and shifting exports to the CVP. By reducing the likelihood of entrainment into CCF, the exposure of listed salmonids to the predator field in CCF is reduced and overall combined survival between the two facilities is expected to increase.

2.5.5.8.5.3.4.5 Risk to sDPS Green Sturgeon to the Operational Changes when ESA-Listed Fish are Present

The risk of entrainment into CCF should be reduced for sDPS green sturgeon. Remaining outside of CCF should be a benefit to individual fish and the overall population as fish will be free to migrate without having their movements delayed by being trapped behind the radial gates leading into CCF.

2.5.5.8.5.3.5 Clifton Court Forebay Aquatic Weed and Algal Bloom Management

2.5.5.8.5.3.5.1 Deconstruct the Action - CCF Aquatic Weed and Algal Bloom Management

DWR has proposed to apply herbicides and use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. Herbicides may include Aquathol[®] K, chelated copper herbicides (copper-ethylenediamine complex and copper sulfate pentahydrate) and

copper carbonate compounds, or other copper-based herbicides; and algaecides may include peroxygen-based algaecides (e.g. PAK 27) to reduce the standing crop of the invasive aquatic weeds or algal blooms growing in the water body. The dominant species of aquatic weeds in the forebay change from year-to-year and can include Egeria densa, curly-leaf pondweed, sago pondweed, and southern naiad; however, other native and invasive aquatic weeds are present as well. Excessive weeds fragment and clog the trashracks and fish screens of the Skinner Delta Fish Protection Facility, reducing operating efficiency and creating conditions in which the screens fail to comply with the appropriate flow and velocity criteria for the safe screening of listed fish. In addition, the weeds create sufficient blockage to the flow of water through the trashracks and louver array, that the pumps at the Banks Pumping Facility begin to reduce the water level downstream of the SDFPF and the loss of hydraulic head creates conditions that lead to cavitation of the impeller blades on the pumps if pumping rates are not quickly reduced. The algal blooms do not affect the pumps, but rather reduce the quality of the pumped water by imparting a noxious taste and odor to the water, rendering it unsuitable for drinking water. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF. Aquatic weed control is included as a conservation measure to reduce mortality of ESA-listed fish species within the CCF.

DWR has applied herbicides in CCF since 1995, typically during the spring or early summer when listed salmonids have been present in CCF. From 1995 to 2006, complex copper herbicide was applied once or twice annually usually during May or June to target early plant growth when the herbicide has greatest efficacy; though applications have occurred as early as May 3rd and as late as September 10th. Copper-based herbicides are very effective at controlling Egeria, the predominant aquatic weed in CCF at that time. DWR temporarily stopped applying herbicides in CCF after the 2006 season when sDPS green sturgeon was listed as a threatened species. New operational procedures for aquatic herbicide applications in CCF were identified in the Modified 2011 Project Description for the CVP and SWP as part of Reclamation's Biological Assessment. The procedures, which limited herbicide applications to July 1 through August 31 (or as authorized by NMFS or USFWS), were developed to allow resumption of aquatic herbicide applications in CCF while avoiding potential toxicity from exposure to copper to salmon, steelhead, and sturgeon. Copper-based herbicides present toxicity issues to salmonids and sDPS green sturgeon due to their high sensitivity to copper at both sublethal and lethal concentrations. In response to an increasing abundance of aquatic weeds that culminated in the failure of several fish louvers of the SDFPF in September 2014, treatments resumed in 2015.

As documented in the 2014 California Department of Food and Agriculture (CDFA) aquatic plant survey, the aquatic weed community in CCF shifted from *Egeria densa*-dominant to pondweed dominant. In August 2015, DWR received approval from NMFS to use endothall, a fast-acting contact herbicide that is effective at controlling aquatic weeds in CCF. DWR selects endothall-based herbicides when aquatic plant surveys indicate that pondweeds are the dominant species, and copper-based herbicides when *Egeria* spp. are the dominant species (Department of Water Resources 2016). Additionally, DWR's 2016 Aquatic Pesticides Application Plan states that since 2006 a mechanical harvester has been used to remove weeds near the outlet from CCF into the approach canal leading to the trash racks in front of the SDFPF. The harvester is used for regular removal of pondweeds to help maintain flows to the SDFPF and Banks Pumping Plant (Department of Water Resources 2016).

Aquatic weed and algae treatments is proposed to occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HAB), or concentration of taste and odor compounds. The frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year, as demonstrated by the history of past applications. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues; or later in the season, when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications. Treatment areas are typically about 900 acres, and no more than 50 percent of the 2,180 total surface acres.

DWR proposes to conduct the following operational procedures:

- Apply Aquathol[®] K and copper-based aquatic pesticides, and use mechanical harvesters, as needed, from June 28 to August 31.
- Apply Aquathol[®] K and copper-based aquatic pesticides, as needed, prior to June 28 or after August 31 if the average daily water temperature within CCF is at or above 25°C and if Delta Smelt, salmonids and sDPS green sturgeon are not at additional risk from the treatment as conferred by NMFS and USFWS.
 - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will
 notify and confer with NMFS and USFWS on whether ESA-listed fish species are
 present and at risk from the proposed treatment.
- Apply Aquathol[®] K and copper-based aquatic pesticides, as needed, during periods of
 activated Delta Smelt and salmonid protective measures and when average daily water
 temperature in CCF is below 25°C if the following conditions are met:
 - Prior to treatment outside of the June 28 to August 31 timeframe, DWR will
 notify and confer with NMFS and USFWS on whether ESA-listed fish species are
 present and at risk from the proposed treatment.
 - The herbicide application does not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within CCF (e.g. after predicted mortality has occurred due to predation or other factors) has been exceeded, and
 - The radial gates remain closed for 24 hours after the completion of the application, unless it is conferred that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present within the CCF.
- Apply peroxygen-based aquatic algaecides, as needed, year-round.
 - There are no anticipated impacts on fish with the use of peroxygen-based aquatic algaecides in CCF during or following treatment.
- Monitor the salvage of listed fish at the SDFPF prior to the application of the aquatic herbicides and algaecides in CCF.
- For Aquathol® K and copper compounds, the radial intake gates will be closed at the entrance to CCF prior to the application of pesticides to allow fish to move out of the

- targeted treatment areas and toward the salvage facility and to prevent any possibility of aquatic pesticide diffusing into the Delta.
- For Aquathol® K and copper compounds, the radial gates will remain closed for a minimum of 12 and up to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in CCF, and to reduce residual endothall concentrations for drinking water compliance purposes. (Contact time is dependent upon pesticide type, applied concentration, and weed or algae assemblage). Radial gates would be reopened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure).
- For peroxide-based algaecides, the radial gates will be closed prior to the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may reopen immediately after the treatment as the required contact time is less than 1 minute and there is no residual by-product of concern.
- Application will be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Aquatic herbicides and algaecides will be applied by boat or by aircraft.
 - Boat applications will be by subsurface injection system for liquid formulations and boat-mounted hopper dispensing system for granular formulations.
 Applications would start at the shoreline and move systematically farther offshore, enabling fish to move out of the treatment area.
- Aerial applications of granular and liquid formulations will be by helicopter or aircraft.
 No aerial spray applications will occur during wind speeds above 15 mph to prevent
 spray drift. Application would be to the smallest area possible that provides relief to SWP
 operations or water quality. No more than 50 percent of CCF will be treated at one time.
- Water quality samples to monitor copper and endothall concentrations within or adjacent
 to the treatment area, per NPDES permit requirements, will be collected before, during
 and after application. Additional water quality samples may be collected during and
 following treatment for drinking water compliance purposes. No monitoring of copper or
 endothall concentrations in the sediment or detritus is proposed.
- No monitoring of peroxide concentration in the water column will occur during and after application as the reaction is immediate and there is no residual. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.
- A spill prevention plan will be implemented in the event of an accidental spill.

DWR proposes to implement additional protective measures to prevent or minimize adverse effects from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within CCF. Additionally, prior to aquatic herbicide applications following gate closures, the water will be drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, and lowers the water level in the CCF to decrease the total amount of herbicide need to be applied, per volume of water, and aides in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of CCF, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the

California Aquaduct via Banks Pumping Plant reduces the exposure time of any fish species present in CCF.

2.5.5.8.5.3.5.2 Assess the Species Exposure

The timing of the application of the aquatic herbicides (Aquathol® K, chelated copper herbicides, and copper carbonate compounds) and mechanical harvesting in the waters of CCF will occur normally during the summer months beginning June 28 through August 31. Some exceptions outside of this time frame are proposed on an "as needed basis" after DWR confers with NMFS and USFWS and it is determined that listed fish are not present in CCF. The probability of exposing salmonids to the endothall- or copper-based herbicides or harvesters during the normal summer application period is very low due to the life history of Chinook salmon and CCV steelhead in the Delta region. Migrations of juvenile winter-run Chinook salmon and CV springrun Chinook salmon primarily occur outside of the summer period in the Delta. CCV steelhead have a very low probability of being in the South Delta during the period proposed for herbicide treatments. Historical salvage data indicate that in wet years, a few CCV steelhead may be salvaged as late as early July, but this is uncommon and the numbers are based on a few individuals in the salvage collections. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the temperatures would be incompatible with salmonid life history preferences. Migrations of juvenile winter-run Chinook salmon and spring-run Chinook salmon primarily occur outside of the summer period in the Delta. CCV steelhead have a low probability of being in the south Delta during late June when temperatures exceed 25°C through August (Grimaldo et al. 2009). In contrast, juvenile and sub-adult sDPS green sturgeon are recovered year-round at the CVP/SWP fish salvage facilities, and have higher levels of salvage during the months of July and August compared to the other months of the year. The reason for this distribution is unknown at present. Therefore, juvenile and sub-adult sDPS green sturgeon are likely to be present during the application of the herbicides or mechanical harvesting.

2.5.5.8.5.3.5.3 Assess Species Response to the Application of Herbicides and Algaecides for the Aquatic Weed Control Program in Clifton Court Forebay

2.5.5.8.5.3.5.3.1 Copper-Based Herbicides and Algaecides

When aquatic plant survey results indicate that *E. densa* is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. Previous applications of copper-based herbicides (Komeen® and Nautique®) have followed the label directions of the product, which limits copper concentration in the water to 1,000 µg/L (1 part per million [ppm] or 1,000 parts per billion [ppb]). The copper in some of the copper-based herbicides is chelated, meaning that it is sequestered within the molecule and is not fully dissociated into the water upon application. Therefore, not all of the copper measured in the water column is biologically available at the time of application. DWR proposes to apply copper herbicides and algaecides in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume and the depth of CCF. Applications of copper herbicides for aquatic weed control will be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR will monitor dissolved copper concentration levels during and after

treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time will be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50 percent of the surface area of CCF will be treated at one time.

Toxicity studies conducted by the California Department of Fish and Game (2004) measured the concentrations of a chelated copper herbicide (Komeen®) that killed 50 percent of the exposed population over 96 hours (96hr-LC50) and 7 days (7d LC50) as well as determining the maximum acceptable toxicant concentration level (MATC) to exposed organisms. CDFG found that the 96hr-LC50 for fathead minnows (*Pimephales promelas*) was 0.31 ppm (0.18 – 0.53 ppm 95 percent confidence limit) and the 7d- LC50 was 0.19 ppm. The MATC was calculated as 0.11 ppm Komeen® in the water column. Splittail (*Pogonichthys macrolepidotus*), a native cyprinid minnow, was also tested by CDFG. The 96hr-LC50 for splittail was 0.51 ppm.

Toxicity studies by Wagner et al. (2017) measured concentrations of a copper carbonate compound (Nautique®) that negatively affected 50 percent of the exposed population over 96 hours (96hr-EC50) and 96hr-LC50. Wagner et al. (2017) found that for brook trout (*Salvelinus fontinalis*), the 96hr-EC50 was 26.2 ppm and the 96hr-LC50 was 28.2 ppm. The same study found that for fathead minnows, the 96hr-EC50 and 96hr-LC50 were 23.0 ppm and 24.4 ppm at 22°C, and 19.6 and 19.7 ppm at 28°C respectively. These values indicate that certain copper carbonate compounds may have higher toxicity at elevated water temperatures (Wagner et al. 2017).

NMFS did not find toxicity data for exposure of sDPS green sturgeon to copper-based herbicides; however, exposure to other compounds including pesticides and copper were found in the literature (Dwyer et al. 2000, Dwyer et al. 2005a, Dwyer et al. 2005b). From these studies, sturgeon species appeared to have sensitivities to contaminants comparable to salmonids and other highly sensitive fish species. Therefore, NMFS will assume that SDPS green sturgeon will respond to copper-based herbicides in a fashion similar to that of salmonids and should have similar mortality and morbidity responses. Pacific salmonids (Oncorhynchus spp.) are very susceptible to copper toxicity, having the lowest LC50 threshold of any group of freshwater fish species tested by the EPA in their Biotic Ligand Model (BLM) (U.S. Environmental Protection Agency 2003) with a Genus Mean Acute Value (GMAV) of 29.11 ppb of copper. In comparison, fathead minnows, the standard EPA test fish for aquatic toxicity tests, have a GMAV of 72.07 ppb of copper. Therefore, salmonids are approximately 3 times more sensitive to copper than fathead minnows. NMFS assumes that sDPS green sturgeon will have a similar level of sensitivity. Hansen et al. (2002) exposed rainbow trout to sub-chronic levels of copper in water with nominal water hardness of 100 mg/l (as CaCO₃). Growth, whole body copper concentrations, and mortality were measured over an 8-week trial period. Significant mortality occurred in fish exposed to 54.1 ppb copper (47.8 percent mortality) and 35.7 ppb copper (11.7 percent mortality). Growth and body burden of copper were also dose dependent with a 50 percent depression of growth occurring at 54.0 ppb, but with significant depressions in growth still occurring at copper doses as low as 14.5 ppb after the 8-week exposure (Hansen et al. 2002).

In a separate series of studies, Hansen et al. (1999a) and Hansen et al. (1999b) examined the effects of low dose copper exposure to the electrophysiological and histological responses of rainbow trout and Chinook salmon olfactory bulbs, and the two fish species behavioral avoidance response to low dose copper(Hansen et al. 1999a, Hansen et al. 1999b). Chinook salmon were shown to be more sensitive to dissolved copper than rainbow trout and avoided copper levels as low as 0.7 ppb copper (water hardness of 25 mg/l), while the rainbow trout avoided copper at 1.6 ppb. Diminished olfactory (i.e., taste and smell) sensitivity reduces the ability of the exposed fish to detect predators and to respond to chemical cues from the environment, including the imprinting of smolts to their home waters, avoidance of chemical contaminants, and diminished foraging behavior (Hansen et al. 1999b). The olfactory bulb electroencephalogram (EEG) responses to the stimulant odor, L-serine (10-3 M), were completely eliminated in Chinook salmon exposed to 50 ppb copper and in rainbow trout exposed to 200 ppb copper within 1 hour of exposure. Following copper exposure, the EEG response recovery to the stimulus odor were slower in fish exposed to higher copper concentrations. Histological examination of Chinook salmon exposed to 25 ppb copper for 1 and 4 hours indicated a substantial decrease in the number of receptors in the olfactory bulb due to cellular necrosis. Similar receptor declines were seen in rainbow trout at higher copper concentrations during the one-hour exposure, and were nearly identical after four hours of exposure. A more recent olfactory experiment (Baldwin et al. 2003) examined the effects of low dose copper exposure on coho salmon (O. kisutch) and their neurophysiological response to natural odorants. The inhibitory effects of copper (1.0 to 20.0 ppb) were dose dependent and were not influenced by water hardness. Declines in sensitivity were apparent within 10 minutes of the initiation of copper exposure and maximal inhibition was reached in 30 minutes. The experimental results from the multiple odorants tested indicated that multiple olfactory pathways are inhibited and that the thresholds of sublethal toxicity were only 2.3 to 3.0 ppb above the background dissolved copper concentration. The results of these experiments indicate that even when copper concentrations are below lethal levels, substantial negative effects occur to salmonids exposed to these low levels. Reduction in olfactory response is expected to increase the likelihood of morbidity and mortality in exposed fish by impairing their homing ability and consequently migration success, as well as by impairing their ability to detect food and predators. In addition, NMFS issued a technical white paper on copper toxicology (Hecht et al. 2007). Given that sDPS green sturgeon use their sense of smell and tactile stimulus to find food within the bottom substrate, degradation of their olfactory senses could diminish their effectiveness at foraging and compromise their physiological condition through decreases in caloric intake following copper exposure.

In addition to these physiological responses to copper in the water, Sloman et al. (2002) found that the negative effect of copper exposure was also linked to the social interactions of salmonids. Subordinate rainbow trout in experimental systems had elevated accumulations of copper in both their gill and liver tissues, and the level of adverse physiological effects were related to their social rank in the hierarchy of the tank. The increased stress levels of subordinate fish, as indicated by stress hormone levels, is presumed to lead to increased copper uptake across the gills due to elevated ion transport rates in chloride cells. Furthermore, excretion rates of copper may also be inhibited, thus increasing the body burden of copper. Sloman et al. (2002) concluded that not all individuals within a given population will be affected equally by the presence of waterborne copper, and that the interaction between dominant and subordinate fish

will determine, in part, the physiological response to the copper exposure (Sloman et al. 2002). It is unknown how social interactions affect juvenile and sub-adult green sturgeon in the wild.

Current EPA National Recommended Water Quality Criteria and the California Toxics Rule standards promulgate a chronic maximum concentration (CMC) of 5.9 µg/l and a continuous concentration criteria of 4.3 µg/l for copper in its ionized form. The dissociation rates for the chelated copper molecules in the copper-based herbicide formulations were unknown at the time of this consultation, so that NMFS staff could not calculate the free ionic concentration of the copper constituent following exposure to water. However, the data from the toxicity studies mentioned above indicates that a maximum working concentration of 1.0 ppm metallic copper will be toxic to salmonids if they are present, either causing death or severe physiological degradation, and therefore, sDPS green sturgeon would likely be similarly affected based on their similar sensitivities to copper toxicity.

2.5.5.8.5.3.5.3.2 Aquathol® K

Aquathol® K is registered for use in California and has effectively controlled pondweeds and southern naiad in CCF and in other lakes. It is available in both liquid and granular formulations. Aquathol® K, the liquid formulation of dipotassium salt of endothall, consists of 40.3 percent of 7-oxabicyclo [2.2.1] heptane-2, 3-dicarboxylic acid equivalent 28.6 percent, which is equivalent to 4.23 pounds of active ingredient per gallon of product. The active ingredient in Aquathol® K is Dipotassium salt of endothall. Endothall is an herbicide in the dicarboxylic acid chemical class (Endothall 1995). While its exact mode of action is unknown, hypotheses include cellular disruption, possibly including interference with protein or lipid synthesis or disrupting the transport of nutrients across cell membranes (Tresch et al. 2011). The potential for bioaccumulation is not fully known. The Forest Service estimates that endothall may have a modest potential for mammalian bioaccumulation (Syracuse Environmental Research Associates Inc. (SERA) 2009), but studies indicate that bioaccumulation in fish is unlikely (Wisconsin Department of Natural Resources (WI DNR) 2012).

The Aquathol® K label recommends application concentrations between 0.75 and 5.0 ppm depending on target plant species, with a maximum of 30 ppm over the course of a treatment season. The EPA maximum concentration allowed for Aquathol® K is 5 ppm. The label requires a 7-day wait period between 5 ppm applications. There are no wind, temperature, or irrigation restrictions on the Aquathol® K label. The concentrated product should not be permitted to contact crops. The endothall concentration in potable water must be less than 0.1 ppm, and application requires a minimum setback of 600 feet from an active potable water intake unless the intake is shut off during treatment. The label states that Aquathol® K should not be used in brackish or saltwater. The NPDES receiving waters limit is 100 ppb.

USEPA approved endothall as a reduced risk herbicide. DWR is proposing to use the dipotassium salt formulation of endothall (as Aquathol® K) and not the amine salt (Hydrothol) formulations, which are highly toxic to fish and invertebrates bioaccumulation (Syracuse Environmental Research Associates Inc. (SERA) 2009). The fish acute and chronic toxicity endpoints for endothall relevant to ESA listed species include: LC50s for Chinook salmon range from 23 ppm to >150 ppm and >100 ppm for coho salmon. One study (Courter et al. 2012) of the effect of Cascade®, an herbicide with the same endothall formulation as Aquathol® K, on salmon and steelhead smolts showed no sublethal effects until exposed to 9-12 ppm. A study on the

ecotoxicity of endothall commissioned by CDBW from 2014 to 2017 reported a wide range of acute effects to fish species ranging from No Observable Effect Concentration (NOEC) for growth and survival effects at the highest concentration tested (NOEC > 500 ppm) for rainbow trout. Figure 2.5.5-33 provides an illustration of endothall estimated Effects Concentration (EC), Lethal Concentration for 50 percent of the organisms (LC50), No Observable Effect Concentration (NOEC), and Lowest Observable Effect Concentration (LOEC) levels for reptile surrogate and fish species. The NPDES permit limit for endothall in receiving waters is 100 ppb. The lowest chronic fish endpoint observed is impaired weight for the fathead minnow at 3.1 ppm and NOEC for Chinook salmon at approximately 3.5 ppm.

When aquatic plant survey results indicate that pondweeds are the dominant species in CCF, Aquathol[®] K will be selected due to its effectiveness in controlling these species. Aquathol[®] K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and CCF depth—Aquathol® labeling (Aquathol SDS) recommends 0.75 ppm to 3.0 ppm for Pondweeds (Potamogeton spp.) (United Phosphorus 2016). The target concentration of treatments DWR proposes is 2 to 3 ppm. Additionally, the duration of exposure to endothall for listed fish will be approximately 12-24 hours. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to 24 hours to reduce the residual endothall concentration for NPDES compliance purposes. DWR will monitor herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol® K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples are submitted to a laboratory for analysis. No more than 50 percent of the surface area of CCF will be treated at one time. Due to the lack of data on effects of Aquathol[®] K to surrogates for sDPS green sturgeon, NMFS will assume that sDPS green sturgeon will respond to Aquathol® K in a fashion similar to that of salmonids and should have similar mortality and morbidity responses. Chinook salmon are affected at low concentrations by endothall and display acute and chronic effects to endpoints at various life stages (juvenile growth and survival are within the range of maximum application concentration). NMFS assumes that sDPS green sturgeon will have a similar level of sensitivity, and are likely to experience negative physiological effects (i.e., reduced growth and survival), and vulnerability to predation as a result of endothall exposure.

2.5.5.8.5.3.5.3.3 Peroxygen-Based Algaecides

PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI). PAK 27, or equivalent product, will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide.

NMFS did not find toxicity data for exposure of salmonids or sturgeon to peroxygen-based algaecides. In a single study, for fathead minnows the 96hr-NOEC was 7.4 ppm and the LC50 was 71 ppm (United Phosphorus 2015). These data reflect low toxicity effects on fish. Due to the

lack of data on effects of peroxygen-based algaecides to surrogates for ESA-listed salmonids or green sturgeon, NMFS will assume that they will respond to peroxygen-based algaecides in a fashion similar to that of fathead minnows and should have similar mortality and morbidity responses. Fathead minnows are only affected at very high concentrations by peroxygen-based algaecides. NMFS assumes that salmonids and sturgeon will have a similar level of sensitivity, and are not likely to experience negative physiological effects as a result of exposure. Therefore, there are no anticipated direct impacts on ESA-listed fish with the use of peroxygen-based aquatic algaecides in CCF. However, it should be noted that decaying algae, killed by peroxygen-based algaecides, can deplete dissolved oxygen levels in the water, which could result in fish mortality. Because the frequency of algaecide applications to control HABs is not expected to occur more than once every few years, and no more than 50 percent of the surface area of CCF will be treated at one time, it is unlikely that algal decomposition will lead to sufficient oxygen depletion to result in fish mortality.

2.5.5.8.5.3.5.4 Assess Species Response to the Mechanical Harvesting for the Aquatic Weed Control Program in Clifton Court Forebay

DWR proposes to continue using mechanical methods to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trashracks. During high weed load periods such as late summer and fall when the plants senesce and fragment or during periods of hyacinth entrainment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in CCF and the intake channel upstream of the trashracks and louvers. The objective is to decrease the weed load on the trashracks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical weed harvester ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading sites, unsafe field conditions such as high winds, and equipment maintenance.

Mechanical aquatic weed control activities associated with the use of harvesters, booms, and automated rakes are likely to result in various stressors (e.g., conveyor mechanism and bycatch, increased turbidity, and low DO) which could increase the likelihood of negative effects to salmonids and green sturgeon in the form of injury, mortality, avoidance activity, gill fouling, and reduced forging capability. The potential for direct and indirect effects to listed species as a result of mechanical removal methods depends on the magnitude (duration and frequency of exposure) of disturbance, the type of method used, and the presence and proximity of listed species in the treatment site. Potential effects of the operation of automated rakes include mortality or injury from contact with the rake, entrapment, removal from water, and temporary disturbance. Automated rakes have the potential to indirectly and directly affect (i.e., injure or kill) listed species if the species are collected along with the aquatic weeds. The operation of a hydraulic rake cleaning system has been shown to trap and kill adult Chinook salmon and other non-listed fish (U.S. Bureau of Reclamation 2016b).

Harvesters, cutters, and shredders have the potential to indirectly (i.e., alter feeding behavior and foraging of prey items) and directly affect (i.e., injure or kill) listed species due to the mechanics of the cutting equipment and, for harvesters, the conveyor belt systems that will be used to remove biomass (and any potential bycatch) from the water. Engel (1995) found that harvesting also has the potential for direct and indirect effects by removing macroinvertebrates, aquatic

vertebrates, forage fishes, young-of-the-year fishes and game fishes (Engel 1995). Additionally, fragmentation caused by cutting may spread invasive plant infestations, and both harvesting and cutting may suspend sediments, temporarily increasing turbidity (Madsen 2000). Madsen (2000) showed that these methods may release nutrients. This finding is supported by a USACE study that determined that shredding had mixed effects on nutrients and dissolved oxygen – plant decomposition tended to increase biochemical oxygen demand and nutrient cycling, but this was offset by increases in algal productivity and the increase in oxygen caused by the shredding machine's mixing of the water (James et al. 2000).

2.5.5.8.5.3.5.5 Assess Risks to Listed Salmonids and sDPS Green Sturgeon

The proposed mechanical harvest and herbicide application program's normal period of application (June 28 through August 31) will substantially avoid the presence of listed salmonids in the CCF due to the run timing of the juveniles through the Delta. As described earlier, CCV steelhead smolts may arrive during any month of the year in the delta, but their likelihood of occurrence is considered very low during the proposed treatment period. It is also highly unlikely that any winter-run Chinook salmon or CV spring-run Chinook salmon will be present during this time period in the South Delta. Unlike the salmonids, however, sDPS green sturgeon have been salvaged during the summer at both the CVP and SWP fish salvage facilities. This is related to their year round residency in the Delta during their first 3 years of life. It is, therefore, likely that individuals from the sDPS green sturgeon will be exposed to the endothall and/or copper herbicides and mechanical harvesting activity, and based on the comparative sensitivities of sturgeon species with salmonids, some of these fish are likely to be killed or otherwise negatively affected. The exact number of fish exposed is impossible to quantify, since the density of sDPS green sturgeon residing or present in CCF at any given time is unknown. The short duration of treatment and rapid flushing of the system will help to ameliorate the adverse conditions created by the herbicide treatment.

The application of herbicides and mechanical harvesting in CCF under the Aquatic Weed Control Program will not affect the populations of winter-run Chinook salmon or CV spring-run Chinook salmon. These populations of salmonids do not occur in the South Delta during the proposed period of herbicide applications and, thus, exposure to individuals is very unlikely. Since no individual fish are exposed, population level effects are absent. Exposure of CCV steelhead is also very unlikely; however, some individual fish may be present during July as indicated by the historical salvage record and, thus, occurrence of fish in CCF during the harvesting and/or herbicide treatments is not impossible. The numbers of CCV steelhead that may be potentially exposed to the harvesting and herbicides is believed to be very small, and therefore demonstrable effects at the population level resulting from exposure are unlikely.

The effects to the sDPS green sturgeon population are much more ambiguous due to the lack of information regarding the status of the population in general. Although NMFS estimates that few sDPS green sturgeon will be exposed during the mechanical harvesting and herbicide treatments, the relative percentage of the population this represents is unknown. Likewise, the number of sDPS green sturgeon that reside in CCF at any given time and their susceptibility to entrainment is also unknown. This uncertainty complicates the assessment of both population and individual exposure risks. This area of sDPS green sturgeon life history needs further resolution to make an accurate assessment of the impacts to the overall status of the population.

2.5.5.9 South Delta Agricultural Barrier Operations

2.5.5.9.1 Deconstruct the Action

DWR proposes to install and operate three agricultural barriers in the channels of the south Delta each year, and Reclamation requests consultation on the installation and operation of these barriers through 2030. A separate biological opinion has been issued by NMFS for the construction effects of installing these barriers and their operations through 2022 to the U.S. Army Corps of Engineers. Two additional permits, the Incidental Take Permit and the Streambed Alteration Agreement, were issued by CDFW for the construction and operations of the barriers and will expire in 2021. Finally, the section 401 Water Quality Certification from the Regional Water Quality Control Board for the south Delta barriers expires in 2022. DWR plans to reinitiate the permitting process for each of these permits prior to their expiration.

DWR constructs the three barriers in the south delta each spring to provide water surface elevation protection for south Delta agricultural diverters [ROC on LTO BA, Appendix A (U.S. Bureau of Reclamation 2019)]. These barriers are constructed on Old River near Tracy, 0.5 miles upstream of the TFCF, on Middle River 0.5 miles upstream of the junction with Victoria Canal, and on Grant Line Canal about 400 feet upstream of the Tracy Boulevard Bridge. The barriers are constructed each spring using large boulders and cobble, and have multiple steel culverts to allow the flow of water through the barrier. The culverts have tidally-operated flap gates which allow the culverts to be completely closed on the ebb tide to trap water behind the barrier, and open on the flood tide to allow water to flow upstream. The center of each barrier is lower than the abutments on each bank and acts as a weir that allows flood tides to overtop it and pass tidal flow upstream. On the ebb tide, water can flow downstream over the weir crest until the upstream water elevation reaches the elevation of the weir crest, at which point the barrier behaves as a low head dam with only minimal river flow passing over it.

When the HORB is not installed, construction of the agricultural barriers may begin on May 1 [Table A5-3, Appendix A (U.S. Bureau of Reclamation 2019)]. Closure of the barriers is typically completed by May 15 and the tidal flap gates tied open. From May 15 to May 31, the tidal flap gates may be untied and become fully functional if DWR clearly demonstrates that water surface elevations in the south Delta are sufficiently low to impact south delta irrigators from diverting water. In addition, the barrier on Grant Line cannot be closed during this period if the Delta smelt incidental take concern limit has been reached. By June 1, both Old River and Middle River barriers can become fully functional and the flap gates left untied. The Grant Line barrier may still be left with the flap gates tied open if there are still Delta smelt incidental take issues. Finally, at least one culvert at each barrier will be kept open to allow for fish passage when water temperatures are less than 22°C even if the previous conditions have been met.

Starting on September 15, the agricultural barriers at Middle River and Old River at Tracy must be notched to allow for the passage of adult fall-run Chinook salmon. At the Grant Line barrier, the appropriate number of flashboards must be removed to provide for passage of adult fall-run Chinook salmon. By November 15, all barriers must be removed from their respective waterways.

Reclamation provided limited information in their BA and supporting documents to assess the impacts of the construction of the three agricultural barriers in the south Delta on listed salmonids and sDPS green sturgeon. Based on previous consultations for the construction of the

agricultural barriers with the U.S. Army Corps of Engineers, the construction of the barriers will create adverse water quality conditions (turbidity and suspended sediment) as well as create disturbances within the three channels of the south Delta where the barriers are located that will negatively affect listed fish present in the waterways during construction. In contrast, sufficient information regarding the impacts of the operations of the south Delta barriers on listed salmonid migration behavior and increased vulnerability to predation was presented (California Department of Water Resources 2018b) to assess the impacts of the operations of the south Delta barriers under this PA component. Therefore, construction of the barriers will be treated programmatically and additional consultation will occur when DWR seeks to renew their permits with state and Federal agencies for the south Delta barriers. Operations of the barriers after construction will be covered by this consultation.

2.5.5.9.2 Assess Species Exposure to Proposed South Delta Agricultural Barrier Operations

2.5.5.9.2.1 Winter-run Chinook Salmon

Adult winter-run Chinook salmon do not spawn in the San Joaquin River basin and, therefore, are unlikely to be present in the location of the south Delta agricultural barriers during their installation and operations. Juvenile winter-run Chinook salmon have the potential to be in the locations of the south Delta agricultural barriers due to their observed presence in the salvage of the TFCF and the SDFPF from January to April. The Middle River and Old River at Tracy barriers are only 0.5 miles away from waterways known to contain juvenile winter-run Chinook salmon (Old River adjacent to the TFCF, and Victoria Canal at the junction with Middle River). Because the PA does not include installation of the HORB in the spring, construction of the barriers does not start until May 1. Therefore, it is unlikely that any juvenile winter-run Chinook salmon will be present in the waters of the south Delta during the construction and operations of the agricultural barriers.

2.5.5.9.2.2 CV Spring-run Chinook Salmon

Both adult and juvenile CV spring-run Chinook salmon are anticipated to be present in the waters surrounding the locations of the south Delta agricultural barriers. Adult CV spring-run Chinook salmon returning to the San Joaquin River basin from the experimental reintroduction population will be entering the waters of the south Delta starting in January and continuing through June with a peak between February and April. These fish will encounter both the construction of the barriers and their operations. Juvenile CV spring-run Chinook salmon from both the San Joaquin River experimental population and the Sacramento River basin populations can be expected to be present in the waters surrounding the south Delta agricultural barriers during construction and operations. Based on historical salvage data, prior to the efforts to reestablish CV spring-run Chinook salmon into the San Joaquin River basin, juvenile CV springrun Chinook salmon were present at the fish salvage facilities from February through June. Since the agricultural barriers on Middle River and on Old River at Tracy are located within close proximity to waterways known to contain CV spring-run Chinook salmon (see winter-run Chinook salmon section above), the presence of juvenile CV spring-run Chinook salmon during construction and operations of the barriers is assumed. Presence of juvenile CV spring-run Chinook salmon from the Sacramento River basin at the Grant Line barrier is also possible given

the effects of tides in these waterways which can push juvenile salmon upstream to the location of the barrier. For juvenile CV spring-run Chinook salmon emigrating from the San Joaquin River basin, the Old River and Grant Line routes are known migratory routes for juvenile Chinook salmon leaving that basin. The emigration of juvenile CV spring-run Chinook salmon (February through June) will completely overlap with the construction and early operations of the barriers (May and June).

2.5.5.9.2.3 CCV Steelhead

Both adult and juvenile CCV steelhead will be present at the locations of the agricultural barriers during construction and operations. Adult CCV steelhead will encounter the barriers during their upstream migrations in fall when the barriers are still in place prior to their removal by mid-November. Adult CCV steelhead migration into the San Joaquin River basin starts in approximately September and continues through early winter (December and January). Juvenile CCV steelhead emigration from the San Joaquin River basin can start in winter but peaks in April and May, which overlaps with the construction and early operations of the barriers. It is also possible to have Sacramento River basin CCV steelhead in the vicinity of the barriers in April and May based on the salvage records from the CVP and SWP fish salvage facilities.

2.5.5.9.2.4 sDPS Green Sturgeon

Both juvenile and adult sDPS green sturgeon are assumed to be present in the waters of the south Delta adjacent to the location of the agricultural barriers. Based on salvage records from the CVP and SWP fish salvage facilities and sturgeon fishing report cards (see Figure 2.5.5-12 and Figure 2.5.5-13), observations of sDPS green sturgeon have occurred year-round in this region.

A summary of the effects of the proposed south Delta agricultural barrier operations is provided in Table 2.5.5-67 in Section 2.5.5.14 Summary Tables of Stressors for each Project Component.

2.5.5.9.3 Assess Response of Listed Salmonids

DWR issued a report regarding the effects of the south Delta agricultural barriers on the survival of emigrating juvenile salmonids, including both Chinook salmon and steelhead (California Department of Water Resources 2018b). The report stated that the presence of the south Delta agricultural barriers will considerably reduce juvenile salmonid survival compared to open channels. Survival is lowest when the barriers are installed and the flap gates are closed. Survival improved when the flap gates were tied open. Survival was also reduced during the construction of the barriers. Juvenile salmonids were typically predated upon upstream of the barriers while delayed on their downstream migration. Predator density increased after the construction of the barriers, but most noticeably upstream of the barriers. The barriers increased the time that juvenile salmonids spent in the vicinity of the barriers, which likely increased their vulnerability to predators located upstream of the barriers. Juvenile salmonids encountering the barriers will move downstream through open culverts preferentially, but few fish were detected moving over the weir crest if the culverts were tied open. If the culverts were tidally operated, fish could only go through when the flood tide pushed them open. Under these conditions, more juvenile salmonids went over the weir crest but could only do so when flows overtopped the weir crest on flood tides or on ebb tides before the water elevations declined to the point where water depth was diminished over the crest. By increasing the time that juvenile salmonids spent in the vicinity of the barriers, the fish were also vulnerable to being exposed to elevated water

temperatures as the season progressed. This could diminish the physiological state of the fish, making them more vulnerable to predation.

The barriers are also likely to present a barrier to upstream migration for adult CV spring-run Chinook salmon that will be moving upstream during the spring through the channels occupied by the barriers. The barriers as described in the PA component do not have notches cut in them during the spring to facilitate upstream passage of adult Chinook salmon. Therefore, it is likely that fish will mill around below the barriers either waiting for the weir crest to overtop on the flood tide and providing a passage route, or seeking passage through the tidal flap gates that will open on the flood tide.

Adult CCV steelhead migrating into the San Joaquin River watershed should encounter barriers with the notches in place (September 15). However, passage is likely only possible during the flood tides or on the falling ebb tide immediately after slack when there is still adequate water depth to facilitate passage.

Under the Proposed Action a portion of the fish from the San Joaquin Basin will route into Old River (HOR) throughout the year at all Vernalis flows. Old River will experience higher velocities towards the export facilities and the San Joaquin River channel will experience lower velocities relative to actual current operations (though these results aren't seen in the modeling results since neither the COS nor PA modeling scenario include spring installation of the HORB). Reach-specific survival (from the Head of Old River to the export facilities) would be expected to improve in the Old River Channel and may decrease in the mainstem San Joaquin River. For purposes of comparing the PA to current operations in terms of the response of listed salmonids, NMFS has assessed effects in the south Delta relative to HORB installation and operations.

Recent modelling (Buchanan 2019) of the effects of the HORB presence on the estimated CCV steelhead survival from the HOR to Chipps Island indicates that survival is higher when the barrier is installed, compared to when it is not installed. The modelling was conducted using acoustic tag data from the 6-year Steelhead Survival Study (2011-2016). The modelling used a generalized linear multinomial regression model to predict survival to Chipps Island as a function of San Joaquin River inflow at Vernalis, migration route taken by the CCV steelhead (Old River versus the mainstem San Joaquin River), and barrier status (installed versus not installed). The model used fixed year effects for the years with Delta inflow (Vernalis) that was less than 5,000 cfs (years 2012-2016 of the 6-year study) and then combined over years in a weighted average using weights equal to the proportion of observations from each year used in the regression model.

Buchanan (2019) found that when the HORB is installed, the probability of total predicted survival from the HOR to Chipps Island was estimated to range from 0.30 (SE = 0.20) for a Vernalis flow of 319 cfs to 0.67 (SE=0.20) for a Vernalis flow of 5,000 cfs. When the barrier was not installed, the estimated predicted survival ranged from 0.17 (SE = 0.13) for a Vernalis flow of 319 cfs, to 0.50 (SE = 0.24) for a Vernalis flow of 5,000 cfs. The predicted difference in survival that was attributable to the presence of the barrier was estimated to range from 0.13 (SE = 0.08) for a Vernalis flow of 319 cfs to 0.19 (SE = 0.08) for a Vernalis flow of 3,889 cfs. Although there is high uncertainty in the predicted survival estimates for both conditions of the barrier's presence, and moderate uncertainty for the predicted effect of the barrier on survival, the predicted survival effect of the barrier (point estimate) was positive for all values of Delta

inflows at Vernalis. The 95 percent confidence intervals excluded zero at flows above 783 cfs. The difference between survival estimates for the barrier installed and the barrier not installed were always positive for the point estimates. Buchanan (2019) cautions that this modelling is based on a limited data set (2011 - 2016). Additional years of data may change the weighting of years, and the yearly effects, as well as routing probabilities used in the preliminary regression model. In general, the current preliminary modelling results indicate that for flows below 5,000 cfs at Vernalis, survival for CCV steelhead emigrating from the San Joaquin River basin is higher when the HORB is installed than when the HORB is not installed.

Based on NMFS's current understanding of survival probabilities based on barrier condition at the Head of Old River, the PA will lead to lower survival of steelhead juveniles emigrating from the San Joaquin River basin by up to 20 percent for flows between 3,800 cfs and 5,000 cfs at Vernalis. This information parallels the information provided by the South Delta Agricultural Barriers Effects Report (California Department of Water Resources 2018b) that indicated reduced survival through the south Delta routes when the agricultural barriers are being constructed and when they are in place. During years in which spring-time Vernalis flows do not exceed 5,000 cfs, Reclamation's PA creates conditions that would reduce steelhead survival to Chipps Island for the Southern Sierra Nevada Diversity Group, further exacerbating the already diminished status of this diversity group.

2.5.5.9.4 Assess Response of sDPS Green Sturgeon

There is an absence of information regarding sDPS green sturgeon behavior around the south delta barriers. Like salmonids, the barriers present a migration blockage for fish moving either upstream or downstream when the barriers are in place. It is unlikely that any sDPS green sturgeon, either an adult or juvenile, will pass over the top of the weir crest, even during flood tides. sDPS green sturgeon may pass through the culverts, but it is unknown whether they will volitionally do this. Fish that are upstream of the barriers after the culverts begin to be tidally operated are likely to be trapped upstream of the barrier. Under these conditions, the only route back to the main Delta waterways may be to swim upstream to the Head of Old River and access the main stem of the San Joaquin River to move back downstream into the Delta.

2.5.5.9.5 Assess Risk to Listed Salmonids

Both juvenile CV spring-run Chinook salmon and juvenile CCV steelhead will encounter the barriers when they are present in the channels of Old River, Middle River, and Grant Line Canal. The barriers will present a substantial impediment to downstream migration both as a physical structure, and as a source of mortality to individuals through predation. Delays in migration can also expose fish to elevated water temperatures as the season progresses, making any prolonged delay potentially lethal due to thermal tolerances of the fish.

2.5.5.9.6 Assess Risk to listed sDPS Green Sturgeon

Both juvenile and adult sDPS green sturgeon will encounter the barriers when they are present in the channels of Old River, Middle River, and Grant Line Canal. The barriers will present a physical barrier to movements within the Delta for both juveniles and adults. It is unknown whether the barriers will increase predation on juvenile sDPS green sturgeon, or diminish their physiological status.

2.5.5.10 Conservation Measures

2.5.5.10.1 Fall Delta Smelt Habitat

2.5.5.10.1.1 Physical Description of Fall Delta Smelt Habitat

Ideal estuarine areas are free of migratory obstructions with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water. Current estuarine areas are degraded as a result of the operations of the CVP and SWP. Historically, the Delta provided the transitional habitat for juvenile fish species to undergo the physiological change to salt water. However, as the location of the low salinity zone (X2) was modified to control Delta water quality, and competing species' needs (*i.e.*, Delta smelt), the Delta served more as a migratory corridor for emigrating anadromous fish species.

Within the central and southern Delta, net water movement is towards the export facilities, altering the migratory cues for emigrating fish in these regions. Operations of upstream reservoir releases and diversion of water from the south Delta have been manipulated to maintain a "static" salinity profile in the western Delta near Chipps Island. This area of salinity transition, the low salinity zone, is an area of high productivity. Historically, this zone fluctuated in its location in relation to the outflow of water from the Delta and moved westwards with high Delta inflow (i.e., floods and spring runoff) and eastwards with reduced summer and fall flows. This variability in the salinity transition zone has been substantially reduced by the operations of the CVP and SWP. The CVP and SWP's long-term water diversions also have contributed to reductions in the phytoplankton and zooplankton populations in the Delta itself as well as alterations in nutrient cycling within the Delta ecosystem. Heavy urbanization and industrial actions have lowered water quality and introduced persistent contaminants to the sediments surrounding points of discharge (i.e., refineries in Suisun and San Pablo bays, creosote factories in Stockton, etc.).

The USFWS' 2008 RPA provided a "Fall X2" standard which requires that the location of the low-salinity zone (defined as 2 parts per thousand [ppt] isohaline) be located at no greater than 46 and 50 miles (74 and 81 km) from the Golden Gate Bridge in September, October, and November of wet and above normal years, respectively, to improve rearing conditions for Delta Smelt. The low-salinity zone magnitude and dimensions change when river flows into the estuary are high, placing low-salinity water over a larger and more diverse set of nominal habitat types than occurs under low flow conditions. During periods of low outflow, the low-salinity zone contracts and moves upstream. Currently, in addition to D-1641, Reclamation operates to reduce entrainment risk and for Delta Smelt fall habitat in wet and above normal water years through releases of water from storage for Fall X2. The USFWS recommended in its designation of critical habitat for the Delta Smelt that salinity in Suisun Bay should vary according to water year type. For the months of February through June, this element was codified by the SWRCB's "X2 standard" described in D-1641 and the Board's current Water Quality Control Plan.

2.5.5.10.1.2 Deconstruct the Action - Fall Delta Smelt Habitat

According to their February 1, 2019 BA, Reclamation proposes to manage for Delta Smelt habitat in the fall of above normal and wet years by releasing additional Delta outflow to move the low salinity zone to beneficial areas to target creation of fall Delta smelt habitat in September

and October following above normal and wet years. Fall Delta smelt habitat would be measured using the physical and biological features of critical habitat; mainly Secchi depth, chlorophyll, water temperature, and salinity. Reclamation would coordinate with USFWS to assess the potential for updating the habitat index to incorporate biotic elements, in particular food (zooplankton prey density), in order to better capture the potential benefits from actions such as operation of the Roaring River Distribution System west-side drain. Achievement of these targets would be assessed using current multi-dimensional Delta models, applying the observed outflow and operations, in addition to other necessary inputs to be developed by Reclamation and DWR.

Reclamation proposes to operate the SMSCG in September and October of above normal and below normal water year types. Iterative analysis using the DSM2 model would be required to identify associated changes in Delta outflow and reservoir releases required to support changes in outflow. The analysis has not been completed and, therefore, the effects of this operation have not been incorporated in the CalSimII model.

The ROC on LTO BA states that the PA would result in X2 being essentially the same as current operations in drier years, but greater (more upstream) than the current operations scenarios in wet and above normal years. Under the current operations scenario, X2 is at 86 km on average in September and 87 km on average in October. Under the PA component, according to the revised Delta Smelt Summer-Fall Habitat Chapter 4 (March 29, 2019 version), Delta outflow could be augmented in above normal or wet years to support a 2 ppt isohaline position of 80 km in September and October. During a May 21, 2019 consultation meeting, Reclamation further clarified that:

"As part of the Delta Smelt Habitat Action, Reclamation intends to meet Delta outflow augmentation in the fall primarily through export reductions as they are the operational control with the most flexibility in September and October of above normal and wet years. Storage releases from upstream reservoirs may be used to initiate the action by pushing the salinity out further in August and early September; however, the need for this initial action will depend on the particular hydrologic, tidal, storage, and demand conditions at the time. In addition, storage releases may be made in combination with export reductions during the fall period during high storage scenarios where near-term flood releases to meet flood control limitations are expected. In these scenarios, Reclamation will attempt to make releases in a manner that minimizes redd dewatering where possible. Additionally, Reclamation will consider an implementation strategy that minimizes upstream effects to listed species and is accounted for in the temperature management plans developed in the spring."

2.5.5.10.1.3 Assess Species Exposure to Fall Delta Smelt Habitat

The Delta waterways function primarily as migratory corridors for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon, but it also provides holding and rearing habitat for each of these species. Juvenile salmonids may use the area for rearing for several months during the winter and spring before migrating to the marine environment. sDPS green sturgeon use the area for rearing and migration year-round. Generally, as flows increase in the fall and through the winter, adult salmon, steelhead, and green sturgeon migrate upstream through the Sacramento and San Joaquin rivers and juveniles migrate

downstream in the winter and spring. Adult winter-run Chinook salmon typically migrate through the Delta between November and June with the peak occurring in March. Adult CV spring-run Chinook salmon migrate through the Delta between January and June. Adult CCV steelhead migration into the Sacramento River watershed typically begins in August, with a peak in September and October, and extends through the winter to as late as May. Adult sDPS green sturgeon start to migrate upstream to spawning reaches in February and their migrations can extend into July, but they may also be found holding in waters of the Sacramento River basin and Delta year-round.

During the proposed Fall Delta Smelt Habitat time period, adult CCV steelhead are typically migrating upstream to spawning grounds in September and October. Juvenile and adult winterrun Chinook salmon and CV spring-run Chinook salmon, as well as juvenile CCV steelhead are unlikely to be present in the Delta at that time. Adult and juvenile sDPS green sturgeon are presumed to be present in the Delta year-round.

In contrast to the Delta region, waters below dams in the Central Valley that may be used to augment Delta outflows may contain various life stages of listed salmonids and sDPS green sturgeon. For example, the river reaches below Shasta and Keswick reservoirs in September and October may contain incubating winter-run Chinook salmon eggs, newly hatched winter-run alevins, or winter-run Chinook salmon fry. In addition, there is the potential to have either adult spring-run Chinook salmon staging to spawn or already spawning, or adult CCV steelhead holding prior to their spawning activities later in the winter. Furthermore, the upper Sacramento River will also hold both adult and juvenile sDPS green sturgeon during the September and October period when water releases to augment Delta outflow may occur. The species and life stage affected by water releases for fall Delta outflow will depend on which reservoir is utilized to make those releases.

A summary of the effects of the proposed fall Delta smelt habitat is provided in Table 2.5.5-68 in Section 2.5.5.14 Summary Tables of Stressors for each Project Component.

2.5.5.10.1.4Assess Response of Listed Species to the Proposed Fall Delta Smelt Habitat

If Reclamation's PA component would augment Delta outflow with upstream reservoir releases, it could affect plans for water temperatures and flows below the reservoir releasing the water the remainder of the year. Releasing additional water from key reservoirs, such as Shasta Reservoir, to support Delta salinity criteria may deplete the cold water pool faster, and thus impact incubating eggs or larval winter-run Chinook salmon in the tail water reaches below Keswick Dam.

A change in Delta outflow or location of the low salinity zone can affect adult CCV steelhead and juvenile and adult sDPS green sturgeon during the fall, as adult CCV steelhead are migrating upstream at this time and sDPS green sturgeon may be migrating or rearing in the Delta. Increased Delta outflow may stimulate adult steelhead to initiate upstream migration earlier as it may resemble a precipitation event in the upper watershed. Changes in Delta outflow and the location of the low salinity mixing zone may influence the location of feeding for juvenile sDPS green sturgeon in the western Delta or influence outmigration of adult green sturgeon following spawning within the Sacramento River mainstem.

Since this aspect of the PA component can be implemented in various ways, effects to species or critical habitat are uncertain and will vary year to year and depending on how the outflow augmentation is implemented. Additionally, Reclamation will consider an implementation strategy that minimizes upstream effects to listed species and is accounted for in the temperature management plans developed in the spring.

2.5.5.10.1.5 Risk to Listed Salmonids and sDPS Green Sturgeon

Since adult CCV steelhead are typically migrating upstream to spawning grounds in the fall, and adult and sDPS green sturgeon may be present in the action area during the PA component, shifting the low salinity zone upstream for 2 months of the year is not likely to substantially alter food resources of other components that may affect listed salmonids or sDPS green sturgeon as they migrate through or rear in the area. No juvenile salmonids are expected to be present at this time, and adult CCV steelhead are entering from the ocean, traveling from a marine environment to freshwater.

Depending on potential changes to exports during the proposed Fall Delta Smelt Habitat action, there may be potential changes to listed fish species migration and survival if outflow is augmented with increased upstream reservoir releases. This could affect plans for water temperatures and flow volumes in both upper river locations and within the Delta. As stated previously, depending on the reservoir making releases to support Delta X2 criteria, different ESUs and DPSs of listed salmonids may be affected. For example, releases made from Shasta Reservoir in September and October may impact eggs and larval winter-run Chinook salmon still in the gravel, and juveniles rearing in the upper Sacramento River below Keswick Dam by depleting the cold water pool necessary for their survival. Since this aspect of the PA component can be implemented in various ways, effects to species or critical habitat are uncertain and will vary year to year and depending on how the outflow augmentation is implemented. Reclamation will attempt to make releases in a manner that minimizes redd dewatering where possible. Additionally, Reclamation will consider an implementation strategy that minimizes upstream effects to listed species and is accounted for in the temperature management plans developed in the spring.

2.5.5.10.2 San Joaquin Basin Steelhead Telemetry Study

2.5.5.10.2.1 Physical Description of the San Joaquin Basin Steelhead Telemetry Study

Salmonids in the San Joaquin River basin were once abundant and widely distributed, but currently face numerous limiting factors. The NMFS Central Valley Recovery Plan identified that 'Very High' stressors for juvenile CCV steelhead outmigration on the San Joaquin River include habitat availability, changes in hydrology, water temperature, reverse flow conditions, contaminants, habitat degradation, and entrainment (National Marine Fisheries Service 2014b). The impacts of these stressors can be studied using acoustic telemetry, and an updated conceptual model, developed by the South Delta Salmonid Research Collaborative (SDSRC) demonstrates how experimental variables of interest to the 6-Year Study (i.e. Delta water operations, tributary water operations, and habitat) are influential in survival and behavior of emigrating smolts. This conceptual model has guided specific hypotheses and investigations of the 6-Year Study.

Reclamation conducted a 6-year steelhead telemetry study on the Stanislaus River (2011-2016) and is proposing to continue an acoustic tagging study on the San Joaquin River to determine entrainment of San Joaquin River origin CCV steelhead into the Tracy and Jones Pumping Plants. The Stanislaus River Research and Monitoring Program is the most comprehensive and longest running salmon and steelhead monitoring programs in California's San Joaquin Basin, although data are not publicly available. Initiated by FISHBIO personnel in 1993 for the Oakdale and South San Joaquin irrigation districts and Tri-Dam Project, the program's suite of ongoing monitoring activities tracks the abundance, distribution, migration characteristics, and habitat use of salmon and steelhead.

2.5.5.10.2.2 Deconstruct the Action - San Joaquin Basin Steelhead Telemetry Study

Reclamation proposes to continue the 6-year steelhead telemetry study for the migration and survival of San Joaquin origin CCV steelhead. The PA component incorporates information from the Salmonid Scoping Team and the 6-year steelhead telemetry study to update protections for San Joaquin origin CCV steelhead, continuing the telemetry studies to further refine measures for protecting CCV steelhead. Details of the environmental parameters to be manipulated during the proposed study have not been provided. NMFS assumes that they will be determined during the study development and that the study will be designed to fit within the proposed operations.

NMFS assumes that hatchery steelhead would be used for the San Joaquin steelhead telemetry study under the PA, which was not specified in the description for this PA component. Reclamation proposes to insert acoustic tags into juvenile (assumed to be hatchery) steelhead to track them as they move through the south Delta. Acoustic arrays would monitor their presence. This study would help fill a gap in knowledge related to the survival of CCV steelhead originating in the San Joaquin River basin. If Reclamation uses hatchery juvenile steelhead for its acoustic telemetry study and export operations do not differ from the proposed PA, this study will be covered for incidental take under this consultation.

However, the details of the acoustic telemetry study were not provided in the PA description. If natural origin CCV steelhead are proposed to be used for the study fish, or if operations of the exports differ from what has been proposed for the PA, then this PA component will be considered as a programmatic consultation.

2.5.5.10.2.3 Assess Species Exposure and Response to the San Joaquin Basin Steelhead Telemetry Study

Wild CCV steelhead and fish species may be affected by hatchery releases, as they would compete for food resources and rearing habitat. However, it is expected that the number of tagged fish would be low compared to the number of wild fish present in the system. Furthermore, the overall survival of tagged fish returning from the ocean as adults to spawn is considered to be very low, thus minimizing the effects of hatchery steelhead straying into the system as a result of the study implementation. The specifics of the proposed telemetry study, including the number of acoustic tagged fish and release timing were not provided in the ROC on LTO BA.

2.5.5.10.2.4 Risk to CCV steelhead

NMFS assumes that attributes of the proposed 6-year study would be similar to the previous study, including sample size, source of tagged hatchery fish, tagging methods, transport, and release timing. The continuation of the steelhead telemetry study will provide important information about the response of fish migration to flows, exports, and other stressors in the San Joaquin River corridor. NMFS also assumes that the study would continue to assess the relationship of exports to flow, route selection at channel bifurcations in the South Delta and mainstem San Joaquin River, survival in the different channels reaches of the South Delta, and ultimately, survival through the Delta to Chipps Island as a whole.

An important aspect of the analysis for CCV steelhead concerns the status of the Southern Sierra Nevada Diversity Group, which is critical to preserving spatial structure of the CCV steelhead DPS. This diversity group, consisting of extant populations in the Calaveras, Stanislaus, Tuolumne, Merced and upper mainstem San Joaquin rivers, is very unstable due to the poor status of each population. This status is due to both project-related and non-project related stressors.

The steelhead telemetry experiment should improve our knowledge base for future consultations. The long-term viability of the Southern Sierra Nevada Diversity Group is expected to depend not only on the continued implementation of the terms and conditions contained within this consultation, but also on actions outside this consultation, most significantly increasing flows in the Tuolumne and Merced rivers.

2.5.5.10.3 Sacramento Deep Water Ship Channel Food Study

2.5.5.10.3.1 Physical Description of the Sacramento Deep Water Ship Channel Infrastructure

The Sacramento Deep Water Ship Channel (SDWSC) is a 43-mile long artificial channel created in 1963 to allow passage of ocean going vessels from Suisun Bay to the Port of Sacramento in West Sacramento. It begins at RM 0 of the Sacramento River and ends at a navigation lock in West Sacramento between the Sacramento River and the SDWSC. It consists of two sections, Suisun Bay to Cache Slough (lower section), and Cache Slough to West Sacramento (upper section). The upper section consists of the ship channel, a triangular harbor and turning basin called Washington Lake, and a barge canal and navigation lock. The W.G. Stone Lock connects the SDWSC to the Sacramento River via the SDWSC barge channel near Sacramento RM 57 for transfer of barges between waterways.

Due to the infrequent usage in the 1980s and 1990s, the lock was de-authorized in 2000, and currently remains in a closed position. However, there is a small amount of water leakage through the lock gate seals. Water exchanges in the SDWSC currently are driven by tidal action. The lack of flow has led to poor water quality conditions, when compared to surrounding areas, conditions in the SDWSC include high salinity and water temperatures, and low DO (Department of Water Resources 2019).

Although discontinued use of the lock has likely reduced the attraction of salmonids to the upper SDWSC, a limited, yet unknown number of fish, currently enter the channel and are observed staging below the locks. The survival of salmon and steelhead that migrate into the upper SDWSC is not known. Prior to ceasing lock gate operations, fish could pass through the open

gates and enter the Sacramento River. Salmon and steelhead that are blocked behind the closed lock gates are thought to be harvested by anglers or die without spawning.

Juvenile salmonids are unlikely to enter the SDWSC from the Sacramento River during their emigration due to the limited flow that enters the SDWSC.

There is a lack of riparian vegetation and large woody debris along the linear ship channel. Emergent aquatic vegetation, comprised of bulrush cattail and three-square bulrush grows sporadically along the edge of the channel; grasses and forbs grow along the levee slopes. Most of the shoreline is covered with riprap or maintained through vegetation removal and rock applications.

2.5.5.10.3.2Deconstruct the Action - Proposed Operations of Sacramento Deep Water Ship Channel Food Study

Reclamation proposes to repair or replace the West Sacramento lock system to hydrologically reconnect the SDWSC with the mainstem of the Sacramento River from mid-spring to late-fall for the purpose of flushing food production into the north Delta to benefit Delta smelt and to provide an alternate migration pathway for fish. Reclamation states that the PA component could result in positive effects on subadult Delta smelt during early fall (U.S. Bureau of Reclamation 2019). The efficacy of the PA component has yet to be tested with pilot studies.

In order to re-operate the lock gates, NMFS assumes construction would be required. Since this is a programmatic action, no specific details of construction activity, timing of lock gate operation, or the portion of Sacramento River flow that would be diverted into the SDWSC were provided at this time. Therefore, only a generalized assessment of effects can be assessed based on fish and water moving through the SDWSC during gate operations.

2.5.5.10.3.3Assess Species Exposure to Proposed Sacramento Deep Water Ship Channel Food Study

Estimates of the number of salmon, CCV steelhead, and sDPS green sturgeon that enter the SDWSC is unknown. However, Chinook salmon and steelhead are known to have previously migrated through the SDWSC prior to their upstream passage being blocked by the W.G. Stone Locks. Adult Chinook salmon likely migrate into the upper SDWSC and hold below the W.G. Stone Lock, possibly attracted to the small of amount of Sacramento River water leaking through an 8-inch crack in the gates. Known species migration timing indicates that adult Chinook salmon may migrate upstream primarily during spring months and are likely blocked by the lock throughout the summer and fall months, and may be present year-round.

Adult winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the sDPS green sturgeon migrate through the Sacramento-San Joaquin Delta waterways on their way to spawning grounds. The Delta also provides holding and rearing habitats for each of these species as they emigrate as juveniles. Juvenile salmonids may use the area for rearing for several months during the winter and spring before migrating to the marine environment. sDPS green sturgeon use the area for rearing and migration year-round. All four species are likely to be present in the Delta or Sacramento River during part of all of the mid-spring to late-fall time period, and therefore would be exposed to the PA. Reconnecting the SDWSC to the Sacramento River would allow part of the river to flow through the SDWSC potentially improving some

water quality parameters. The PA component could also increase the mobilization of accumulated sediment in the channel, which could contain historical pesticides or other contaminants, possibly affecting listed fish species present in the SDWSC or downstream.

Assuming that the repair or replacement of the lock system would involve construction activities such as dredging and pile driving, effects from suspended sediment and noise would be expected, and would likely include decreased DO, increased turbidity, and mobilization of toxic chemicals, according to the Central Valley Regional Water Quality Control Board basin plan (California Regional Water Quality Control Board 2018). Since detailed construction activities were not provided to NMFS, effects to species from construction activities could not be analyzed at this time. A summary of the effects of the proposed SCWSC food study is provided in Table 2.5.5-69 in Section 2.5.5.14 Summary Tables of Stressors for each Project Component.

2.5.5.10.3.4Assess Response of Species to the Proposed Sacramento Deep Water Ship Channel Food Study

Estimates of the number of adult salmon, CCV steelhead, and sDPS green sturgeon that enter the SDWSC and follow it upstream to the lock is unknown. However, existing information indicates that adult Chinook salmon and steelhead migrate into the SDWSC and their upstream passage is blocked by the W.G. Stone Locks. Re-opening the gates may allow adult salmonids and potentially sDPS green sturgeon to migrate between the Sacramento River and SDWSC, which would likely benefit fish that would otherwise be blocked. An increase in flow through the SDWSC may also cause a false attraction for adult salmonids and sDPS green sturgeon, leading to more adults entering the SDWSC rather than migrating up their natural route through the Sacramento River.

Allowing flow to enter the SDWSC from the Sacramento River during times of year when juvenile salmonids are outmigrating, may change their route, taking them through the SDWSC rather than through their natural migration route down the Sacramento River. Survival in the SDWSC in unknown, however, it would likely result in decreased survival, due to potential predation and lack of suitable rearing habitat. In-channel large woody debris and shaded riverine aquatic (SRA) habitats are important components for rearing salmonids because they contribute to shade, food production, and cover from predators. The sparse and sporadic distribution of these habitats, in addition to mobilizing potentially contaminated sediment in the SDWSC, limit the value of the channel as rearing habitat for salmon, CCV steelhead, and sDPS green sturgeon.

Opening the W.G. Stone Locks would facilitate the upstream passage of adult salmonids and sDPS green sturgeon, but may also divert juvenile salmon and sDPS green sturgeon from the Sacramento River downstream into the SDWSC. Closing or opening the gates may attract increased numbers of adult salmon and sDPS green sturgeon upstream into the SDWSC which may become trapped or delayed behind the gates when they are closed. The primary factors affecting the species' survival within the SDWSC include freshwater flows through the lock, tidal exchange, water temperatures, water quality, riparian habitat, angler harvest, and predation. ESA-listed fish species may be affected by creating false attraction flows, blocking adult salmon and sDPS green sturgeon behind the lock gates, creating unfavorable juvenile outmigration conditions, and reducing the number of individuals that escape to the Pacific Ocean or migrate upriver to spawn. Furthermore, an additional risk for adult sDPS green sturgeon is the

vulnerability of vessel strikes from large ocean going vessels transiting the SDWSC while traveling to or from the Port of Sacramento.

Potential effects from construction activity may include temporary effects from increased turbidity, decreased DO, and pile driving activities. Since detailed activities were not provided, effects to fish are not analyzed at this time.

2.5.5.10.4 North Delta Food Subsidies / Colusa Basin Drain and Suisun Marsh Roaring River Distribution System Food Subsidy Studies

2.5.5.10.4.1 Physical Description of the Colusa Basin Drain, and Suisun Marsh Roaring River Distribution System

The Colusa Basin drain, located near the town of Dunnigan, California, provides drainage for surface runoff as well as agricultural discharge. The drain also serves as a water source for irrigation users. In the fall, during high irrigation use, water flows from the Colusa Basin drain through Knights Landing outfall gates into the Sacramento River or into Yolo Bypass.

Suisun Marsh is a large brackish marsh area that is part of the San Francisco Bay tidal estuary. It is formed primarily by the confluence of the Sacramento and San Joaquin rivers between Martinez and Suisun City, California. The Suisun Marsh facilities are jointly operated by the CVP and SWP, and include the Suisun Marsh Salinity Control Gates (SMSCG), Roaring River Distribution System (RRDS), Morrow Island Distribution System (MIDS), and Goodyear Slough Outfall.

The SMSCG are located on Montezuma Slough about 2 miles downstream of the confluence of the Sacramento and San Joaquin rivers, near Collinsville, California. The purpose of gate operation is to decrease the salinity of the water in Montezuma Slough to meet salinity standards set by the SWRCB and Suisun Marsh Preservation Agreement. The SMSCG control salinity by lowering gates during flood tides to prevent flow of higher salinity water from Grizzly Bay into Montezuma Slough and opening gates during ebb tides to retain the lower salinity Sacramento River water that entered the marsh during the previous ebb (outgoing) tide. Currently, SMSCG operation occurs from October to May (~10-20 days) where radial gates are lowered during the flood tides and opened during the ebb tides, flashboards are in place through September, and a boat lock is operated as-needed for passing vessels. Outside of the period, the radial gates remain open, flashboards are removed, and operation of the boat lock is not needed. As of 2018, gates are operated during August in "below normal" or "above normal" water years in addition to October to May operation.

Roaring River is located north of Honker Bay. The RRDS diverts water from Montezuma Slough through a bank of eight 60-inch-diameter culverts. RRDS is equipped with fish screens into the Roaring River intake pond during high tides, in order to raise the water surface elevation in RRDS above the adjacent managed wetlands. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately owned turnouts on the system.

2.5.5.10.4.2 Deconstruct the Action - Proposed Food Subsidies

2.5.5.10.4.2.1 North Delta Food Subsidies / Colusa Basin Drain

Reclamation proposes to increase food entering the north Delta through flushing nutrients from the Colusa Basin into the Yolo Bypass and north Delta. DWR, Reclamation, and water users would work with partners to flush agricultural drainage water from the Colusa Basin Drain through Knights Landing Ridge Cut and the Tule Canal to Cache Slough, to potentially increase aquatic food resources in the north Delta for fish. Reclamation would work with DWR and partners to augment flow in the Yolo Bypass in July and/or September by closing Knights Landing Outfall Gates and routing water from Colusa Basin into Yolo Bypass to promote food production for fish. Under the PA component, approximately 24,000 acre-feet (AF) of agricultural water would be diverted over a 4-week period (during July, August, and/or September) from Colusa Basin into Yolo Bypass rather than out falling into the Sacramento River. This would result in increased flow in Yolo Bypass during late summer. Since this is a programmatic action, the ROC on LTO BA does not provide sufficient detail to conduct an indepth effects assessment for this PA component. Therefore, the assessment of PA effects will be a very high level overview of this PA component and not adequate for a full consultation. Therefore, this PA component will be considered as a programmatic consultation.

2.5.5.10.4.2.2 Suisun Marsh Food Subsidies

Reclamation proposes to increase food production for fish in Suisun Marsh through coordinating managed wetland flood and drain operations in Suisun Marsh, RRDS food production, and reoperation of the SMSCG in June through September in above normal and below normal years. As noted in the Delta Smelt Resiliency Strategy, the purpose of this management action is to attract Delta smelt into the high-quality Suisun Marsh habitat, reducing use of the less food-rich Suisun Bay habitat (California National Resources Agency 2016). Infrastructure in the RRDS would be used to help drain food-rich water from the canal into Grizzly Bay to potentially augment Delta smelt food supplies in that area.

In addition to the current October through May operation to meet Suisun Marsh water quality standards, Reclamation proposes operating the SMSCG on the tidal cycle in below normal and above normal years in June through September for 60 days, not necessarily consecutive, to improve Delta smelt critical habitat. Under the PA component, Reclamation and DWR would increase tidal operations of the SMSCG to direct more fresh water in Suisun Marsh to reduce salinity, increase food, and improve habitat conditions for Delta smelt. In addition to current operation, SMSCG would operate in June to September in above normal and below normal years. This would be combined with RRDS management for food production and flushing freshwater through the RRDS to increase the low salinity habitat in Grizzly and Honker bays. Reclamation and DWR will continue to meet existing D-1641 salinity requirements in the Delta and Suisun Marsh. Since this is a programmatic action, the ROC on LTO BA does not provide sufficient detail to conduct an in-depth effects assessment for this PA component. Therefore, the assessment of PA effects will be a very high level overview of this PA component and not adequate for a full consultation. Therefore, this PA component will be considered as a programmatic consultation.

2.5.5.10.4.3 Assess Species Exposure to Proposed Food Subsidies

Reclamation proposes to route approximately 24,000 AF of agricultural water through the Colusa Basin Drain to the Cache Slough area through the Yolo Bypass during the months of July to September. The timing of observations of listed species in the Delta are determined by Delta Juvenile Fish Monitoring Program (DJFMP) (U.S. Fish and Wildlife Service 2014, 2015b, 2016a, 2017)(USFWS 2000-2016), which conducts annual monitoring of fishes to determine abundance and distribution of juvenile salmonids and other species. According to DJFMP data, juvenile winter-run Chinook salmon are primarily present in the Delta from November to April, juvenile CV spring-run Chinook salmon are present primarily from December through May, and juvenile CCV steelhead were determined to be present in the Delta primarily from December to July. According to DJFMP and salvage data, and sDPS green sturgeon are present year-round.

Adult winter-run Chinook salmon are present in the Delta from November to June as they migrate from the ocean up the Sacramento River to their spawning grounds. Adult CV spring-run Chinook salmon are present in the Delta from January through June (California Department of Fish and Wildlife 1998, Yoshiyama et al. 1998, Moyle 2002). Adult CCV steelhead are present in the Delta from August to October on their way to the northern Central Valley tributaries (Moyle 2002), and from March to May on their return to the ocean (Hallock et al. 1961). For San Joaquin River origin fish, adult CCV steelhead peak in November through January (California Department of Fish and Game 2007). There are limited data on the residence time and run timing of adult CCV steelhead of both Sacramento and San Joaquin River origin in the Delta. Adult sDPS green sturgeon may be present in the Delta during all months of the year (Moyle et al. 1995, Heublein et al. 2009).

A summary of the effects of the proposed north Delta food subsidies/Colusa Basin Drain is provided in Table 2.5.5-70 in Section 2.5.5.14 Summary Tables of Stressors for each Project Component.

2.5.5.10.4.4 Assess Response of Listed Species to the Proposed Food Subsidies

The PA component has the potential to increase the exposure of fish to harmful contaminants through diversion of agricultural drainage into the Sacramento River. Chemical forms of water pollution are a major cause of freshwater habitat degradation worldwide. There are many sources of contaminants, and these reflect past and present human activities and land use (Scholz and McIntyre 2015). Contaminants are typically associated with areas of urban development, agriculture, or other anthropogenic activities. Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element (i.e., heavy metals) concentrations may have deleteriously effects on survival of fish in the Central Valley watersheds.

One of the contaminants potentially present is selenium, which was identified as one of the pollutants in San Francisco Bay and the western Delta on the Clean Water Act section 303(d) list (State Water Resources Control Board 2010a). Within the Delta, there are multiple sources of selenium. Presser and Luoma (2013) identify oil refinery wastewaters from processing crude oils at North Bay refineries and irrigation drainage from agricultural lands in the western San Joaquin Valley (mainly via the San Joaquin River) as the two primary sources. Agricultural drainage in the Sacramento Valley west-side creeks in the Yolo Bypass and non-oil industries and wastewater treatment effluents are minor sources of selenium in the Delta. Selenium can elicit a short- and long-term response from aquatic biota depending on the quantity, quality, and

duration of selenium exposure. The primary exposure pathway for fish and other aquatic organisms to selenium is through their diet (Stewart et al. 2004, Presser and Luoma 2010a, Presser and Luoma 2010b, 2013). Continued exposure of selenium can result in bioaccumulation and/or toxicity to fish in the Delta. Because adult salmon and steelhead do not forage extensively while in the Delta before spawning upstream in the rivers (Sasaki 1966), their exposure is likely to be much less than exposure for juveniles, which spend most of their time in the Delta feeding and foraging for food. Thus, survival and growth of juvenile salmonids may be affected by potential contaminant exposure, due to the timing in which those juveniles occur and feed within the action area. sDPS green sturgeon migrate from major rivers to the Delta and reside within the Delta or in the Pacific Ocean (U.S. Fish and Wildlife Service 2008). Therefore, all life stages of sturgeon have the potential to be exposed to contaminants in the Delta.

At Suisun Marsh, the SMSCG would be operated for 60 days in June to September in above normal and below normal years and up to 20 days during October to May. SMSCG would be operated for a total of up to 80 days year-round, primarily during summer months. NMFS assumes the boat lock would remain in the open position during operation, allowing fish passage when gates are closed. Operation of the SMSCG from October through May coincides with the upstream migration of adult Central Valley anadromous salmonids and sDPS green sturgeon. The late winter and spring downstream migration of Central Valley salmonids also overlaps with the operational period of the SMSCG. During summer operations, juvenile and adult CCV steelhead and sDPS green sturgeon are present in the Delta, and potentially adult winter-run Chinook salmon and CV spring-run Chinook salmon during June. During the majority of the year, the SMSCG will not be operated and no fish passage delays due to the gates are anticipated. However, during the annual 70 to 80 days of periodic operation, individual adult salmonids and sDPS green sturgeon may be delayed in their spawning migration from a few hours to several days. If the destination of a pre-spawning adult salmon or CCV steelhead is among the smaller tributaries of the Central Valley, it may be important for migration to be unimpeded, since access to a spawning area could diminish with receding flows. sDPS green sturgeon spawn in the deep turbulent sections of the upper reaches of the Sacramento River, and spring stream flows in the mainstem Sacramento River are generally not limiting their upstream migration. It is also common for sDPS adult green sturgeon to linger for several days in the Delta prior to initiating their active direction migration to the upper Sacramento River (Vogel 2008).

2.5.5.10.4.5 Assess Risk to Listed Fish Species

ESA-listed fish species that are most likely to be present during the North Delta Food Subsidies/ Colusa Basin Drain PA component include juvenile and adult sDPS green sturgeon and adult CCV steelhead. Since the PA component includes diversions that would occur during the summer and early fall, most ESA-listed species are unlikely to be present in the Yolo Basin, Tule Canal, Toe Drain, or Cache Slough complex during this period of time. However, the project description does not provide specific details such as expected changes to water temperature or contaminant load of the diverted agricultural water and therefore, impacts cannot be fully analyzed at this time. Only generalized impacts will be considered in this analysis. This PA component will be considered as a programmatic consultation.

The proposed Suisun Marsh Food Subsidies action could affect all four listed species present in the Suisun Marsh, Suisun Bay, Grizzly Bay, and Honker Bay since SMSCG operation would occur year-round, however, operation would only occur up to 80 days of the year.

Migrating salmonids and sDPS green sturgeon may be affected by the operation of the SMSCG, as it may delay their movement. If the SMSCG are in operation, the gates will open and close twice each day with the tides. On the ebb tide, the gates are open and fish will pass downstream into Montezuma Slough without restriction. On the flood tide, the gates are closed and freshwater flow and the passage of juvenile fish will be restricted. Salmonid smolt predation by striped bass and pikeminnow could be exacerbated by operation of the SMSCG since these predatory fish are known to congregate in areas where prey species can be easily ambushed. However, operation of the SMSCG would be limited to only periods required for compliance with salinity control standards, and this operational frequency is expected to be no more than 80 days per year, mostly during summer months when smolts are unlikely to be present. Therefore, the SMSCG will not provide the stable environment which favors the establishment of a local predatory fish population and the facility is not expected to support conditions for an unusually large population of striped bass and pikeminnow. In addition, most listed Central Valley salmonid smolts reach the Delta as yearlings or older fish.

The project description did not include specific details on water quality in the Colusa Basin Drain or whether the SMSCG boat lock would be open during operation or when the flashboards would be installed and removed. In order to fully assess impacts of the PA to ESA-listed fish species for the North Delta and SMSCG Food Studies, more information should be provided. Therefore, this PA component will be considered a programmatic consultation.

2.5.5.10.5 Habitat Restoration in the Bay/Delta

2.5.5.10.5.1 Tidal Habitat Restoration 8,000 acres (U.S. Fish and Wildlife Service 2008)

All ESA-listed salmonids and sturgeon must pass through the Delta during their migration to the Pacific Ocean. Although rearing and migration through the Delta represents a short period of these fish's overall life-cycle, a large proportion of juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon are expected to be exposed to 8,000 acres of tidal habitat restoration in the Delta. Tidal habitat restoration is expected to benefit juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and southern DPS green sturgeon in several aspects, including increased food availability and quality, and refuge habitat from predators. These benefits can be manifested by higher growth rates in fish utilizing these habitats and increased survival through the Delta.

The in-water construction work window for tidal and channel margin restoration under the PA component is August–October. The following life stages of the listed salmonids and sDPS sturgeon are expected to be present in the Delta during this period and have the potential to be exposed to impacts from in-water construction: immigrating adult CCV steelhead; juvenile sDPS green sturgeon; and some emigrating adult sDPS green sturgeon. Few if any juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead are expected to be present during the in-water construction work window. Reclamation lists the following potential effects to listed salmonids and sDPS green sturgeon from construction of restoration projects in the ROC on LTO BA (U.S. Bureau of Reclamation 2019):

"temporary loss of aquatic and riparian habitat leading to increased predation, increased water temperature, and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of

suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance, indirect impairment of aquatic ecosystem productivity, loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams. The risk from these potential effects would be minimized through application of AMMs (Appendix E, Avoidance and Minimization Measures)."

Reclamation also states in the ROC on LTO BA that "Reclamation and DWR will consult on future tidal habitat restoration with USFWS and NMFS on potential effects to fish from construction-related effects." Due to the lack of specifics project elements and details regarding implementation, and success criteria, this PA component will be considered as a programmatic consultation.

2.5.5.10.5.2 Predator Hot Spot Removal

Predator hot spot removal under the PA component (April 30, 2019; Appendix A2) is intended to improve conditions for downstream-migrating juvenile salmonids, including winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. The PA component may focus removal efforts where predators are likely concentrated along the primary migratory routes of juvenile Chinook salmon [e.g., hotspots identified by Grossman et al. (2013)]. However, implementation of the PA component could also improve conditions for all life stages of CCV steelhead and potentially juvenile sDPS green sturgeon emigrating downstream. The ultimate effect of predator hotspot removal on juvenile salmonid and sDPS green sturgeon survival is uncertain. Hotspots are limited in scale relative to overall available habitat and previous research has not found a consistent positive effect of predator removal on juvenile salmon survival (Cavallo et al. 2012, Michel et al. 2015, Sabal et al. 2016). In general, there is a lack of detail and specificity in the BA to conduct a thorough effects analysis for this PA component. Analysis of the PA component effects are general in nature and will be considered as a programmatic consultation.

2.5.5.10.5.2.1 Deconstruction of the Predator Hot Spot Removal

Reclamation proposes to remove potential predator hot spots that occur in waters of the Delta. These hot spots may include in-water structures such as abandoned docks, outfalls, pump platforms, or pilings, removing overhead lighting at bridges and fish screens that illuminate the water surface at night, or filling in scour holes or other anomalies in the bathymetry that attract predators. The ROC on LTO BA does not identify exact locations or the process that will be undertaken to remove these predator hotspots.

2.5.5.10.5.2.2 Assess Exposure to of Listed Species to Predator Hot Spot Removal

In-water construction at predator hot spot removal locations in the lower Sacramento River and Bay/Delta is proposed to occur during the in-water work windows through the summer months, when juvenile listed salmonids are generally still located in the upper river sections of the Sacramento River and San Joaquin River basins. However, the starting and endpoints for the in-

water work window were not defined in the BA. Based on the summer in-water work window, construction actions at hot spot locations is not anticipated to effect juvenile salmonids but could occur when rearing juvenile sDPS green sturgeon are present, due to the year-round use of the Delta by juvenile sDPS green sturgeon for rearing. In addition, locations in the northern Delta could have removal of the hot spots overlap with the presence of adult CCV steelhead, which are migrating through the system in large numbers from August through November.

2.5.5.10.5.2.3 Assess Response of Listed Salmonids to Predator Hot Spot Removal

Since the ROC on LTO BA has not described the methods proposed to remove predator hot spots, it is difficult to assess the response of listed salmonids or sDPS green sturgeon to these actions. NMFS anticipates that heavy construction actions will need to take place to remove structures or pilings in the water, as well as to fill in scour holes or other bathymetry anomalies that attract predators. Typically, heavy construction actions create noise and vibrations in the surrounding aquatic environment that will disturb any fish located in the proximity of the action. Filling in scour holes, typically with some sort of rock substrate, may entail potential crushing or injuries due to the dumping of fill materials into the water column. Normally, any fish present at the onset of such construction activities will leave the location of the disturbance and thus avoid any negative effects.

2.5.5.10.5.2.4 Assess Response of sDPS Green Sturgeon to Predator Hot Spot Removal

Although details of the PA components for this action are minimal, NMFS anticipates that responses of sDPS green sturgeon to construction related actions to remove predator hotspots will be similar to listed salmonids. Individuals from the sDPS green sturgeon population may be more susceptible to the construction related actions to remove predator hot spots in the Bay/Delta region due to their year-round presence in the Delta. Elevated construction activity is anticipated to drive sDPS green sturgeon away from areas of the predator hot spot removal as individuals attempt to avoid disturbances in the aquatic environment. As stated previously, the lack of detail in the ROC on LTO BA regarding the predator hot spot action limits the assessment of effects to listed sDPS green sturgeon.

2.5.5.10.5.2.5 Assess Risk to Listed Salmonids from Predator Hot Spot Removal

NMFS anticipates that there will be low risk to juvenile listed salmonids associated with the removal of predator hot spots due to the timing of such work. Juvenile listed salmonids are expected to be upriver of the Delta during the summer, and thus will not be exposed to any of the construction actions required to remove identified predator hot spots in the Delta. On the other hand, adult CCV steelhead migrating into the Sacramento River basin may be exposed to the effects of any construction actions required to remove predator hot spots. These fish may be exposed to increased levels of sound, vibrations, or activities along the banks of migratory channels. In most instances, these disturbances will potentially cause migratory delays, or rerouting of fish into migratory pathways with less activity. In the most extreme cases, exposure to the construction activities could cause injury or death. Implementation of the proposed AMMs will reduce the level of risk associated with the construction actions. After removal of in-water structures or other features that create predator hotspots, migratory success of juvenile salmonids should be enhanced. However, the improvement may be transitory or less than anticipated due to the behavior of predators, and the potential that predators would move to adjacent habitat. It

should be noted that the lack of detail in the description of this PA component limits the level of detail in assessing the risk to listed salmonids. Therefore, this PA component will be considered as a programmatic consultation.

2.5.5.10.5.2.6 Assess Risk to Listed sDPS Green Sturgeon from Predator Hot Spot Removal

NMFS anticipates that overall there will be a low to medium risk to juvenile sDPS green sturgeon associated with the removal of predator hot spots in the Delta due to the distribution of individual green sturgeon across the Delta. The greatest risk will come from activities that fill in scour holes or other bathymetric anomalies that attract predators. Such habitat would also tend to attract sDPS green sturgeon due to the increased water depth, thus providing a higher level of overlap between the presence of sDPS green sturgeon and the activities associated with predator hot spot removal. However, the BA does not identify the numbers or locations of such deep water habitat that would be identified as a predator hot spot, thus providing a detailed assessment of the level of risk is not possible. This PA component will be considered as a programmatic consultation.

2.5.5.10.6 Fish Intervention

2.5.5.10.6.1 Reintroduction efforts from Fish Conservation and Culture Laboratory

The existing Fish Conservation and Culture Laboratory (FCCL) located adjacent to the SDFPF at the SWP will be used to begin Delta smelt production to supplement the natural Delta smelt population. Information developed through the operations of the FCCL will be used to create a supplementation strategy and inform the construction of the new conservation hatchery. The culture of Delta smelt at the FCCL does not utilize or expose any listed salmonid or sDPS green sturgeon to capture or handling. The facility is located outside of designated critical habitat for CCV steelhead and sDPS green sturgeon on the inlet channel to the Banks Pumping Plant of the SWP. It is not expected that the release of cultured Delta smelt back into the Delta, its historical native habitat, will have any negative impacts on listed salmonids or sDPS green sturgeon present in the Delta.

2.5.5.10.6.2 Delta Fish Species Conservation Hatchery

The operation of the Delta Fish Species Conservation Hatchery would not provide benefits to any life stage of winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon. Potential negative effects of the Delta Fish Species Conservation Hatchery include inadvertent propagation and spread of invasive or nuisance species, which could affect listed salmonids and sDPS green sturgeon through changes in food web structure. Additional impacts could include reduced water quality resulting from hatchery discharge. Potential negative effects from discharged water are expected to be minimal due to the water sterilization treatments for pathogens and invasive species and the very small size of the discharge compared to flows in the Sacramento River near the hatchery location. Mitigation and minimization measures detailed in the EIR/EIS for the facility (Horizon Water and Environment 2017) indicate that potential impacts are less than significant. Potential exposure of juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon would be restricted to a small spatial area within the primary migration route and rearing habitat where

effluent from the Delta Fish Species Conservation Hatchery discharges into the Sacramento River.

As with the other proposed construction activities in the Bay-Delta, few if any juvenile winterrun Chinook salmon, CV spring-run Chinook salmon, or CCV steelhead would be expected to be exposed to the effects of construction of the Delta Fishes Species Conservation Hatchery based on the timing of in-water construction (August-October) and the typical seasonal occurrence of these fish in the Delta. There may be some exposure of early or late migrating juvenile salmonids to in-water and shoreline construction of the hatchery intake and outfall. The year-round occurrence of juvenile sDPS green sturgeon in the Delta means that this life stage, as well as adult sDPS green sturgeon occurring in the Delta during May to October, could be exposed to Delta Fish Species Conservation Hatchery construction under the PA component. Individuals occurring near the construction site could be subject to effects similar to those previously described for habitat restoration (e.g., temporary loss of habitat leading to predation, degraded water quality, reduced foraging ability caused by reduced visibility, noise-related delay in migration, and direct effects from contact with construction equipment or isolation/stranding within enclosed areas). The risk from these potential effects would be minimized through application of AMMs [U.S. Bureau of Reclamation (2019): Appendix E, Avoidance and Minimization Measures]. There is low potential for exposure because of the in-water work window, the application of AMMs, and the small scale of the in-water construction. However due to the lack of specific plans and construction schedule that may require years to complete the facility, a full effects analysis cannot be conducted. Therefore, this PA component will be considered as a programmatic consultation.

2.5.5.11 Supplemental Analysis of June 14, 2019, Final PA

During consultation for this opinion, discussions between NMFS and Reclamation resulted in revisions to the PA that were not captured in the February 5, 2019, BA that was used for the majority of the analysis in this opinion. It was not possible to include these revisions in any modeling due to the White House memorandum that mandated issuance of final biological opinions within 135 days of the January 31, 2019 (June 17, 2019, and subsequently extended to July 1, 2019). The effects description above (Section 2.5.5.1-2.5.5.10) was (unless otherwise noted) based on the modeling associated with the February 5, 2019 PA (Appendix A1, the original PA), and associated modeling that NMFS requested. The following subsection provides a supplemental effects analysis to assess the effects of the June 14, 2019 PA revisions reflected in the final PA (Appendix A3), including a discussion of whether and how the PA revisions modify the effects analyzed above.

2.5.5.11.1 Revisions to OMR Management

As a result of discussions, the OMR management section of the PA included sufficient changes and that the final PA (Appendix A3) shows most of the PA component as new text – not changes relative to the February 5, 2019 PA. All details of the revised OMR Management component of the PA are excerpted below; bold, italicized, text is used to highlight key changes assessed in this supplemental analysis.

Onset of OMR Management:

"Reclamation and DWR shall start OMR management when one or more of the following conditions have occurred:

- Integrated Early Winter Pulse Protection ("First Flush" Turbidity Event): To minimize project influence on migration (or dispersal) of Delta Smelt, Reclamation and DWR proposes to reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period shall not be more negative than -2,000 cfs, in response to "First Flush" conditions in the Delta. The population-scale migration of Delta Smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo et al. 2009, Sommer et al. 2011). Thereafter, the best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polansky et al. 2017)). "First Flush" conditions may be triggered between December 1 and January 31 and include:
 - o running 3-day average of the daily flows at Freeport is greater than 25,000 cfs and
 - o running 3-day average of the daily turbidity at Freeport is 50 NTU or greater, or
 - o real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment.

This "First Flush" action may only be initiated once during the December through January period and will not be required if:

- water temperature reaches 12 degrees Celsius based on a three station daily mean at Honker Bay, Antioch, and Rio Vista, and/or
- o ripe or spent Delta Smelt are collected in monitoring surveys.

Salmonids Presence: After January 1, if more than 5 percent of any one or more salmonid species (wild young-of-year Winter-Run, wild young-of-year Spring-Run, or wild Central Valley Steelhead) are estimated to be present in the Delta as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling."

Additional Real-Time OMR Restrictions and Performance Objectives:

"Reclamation and DWR shall manage to a more positive OMR than -5,000 cfs based on the following conditions:

• Turbidity Bridge Avoidance ("South Delta Turbidity"): After the Integrated Early Winter Pulse Protection (above) or February 1, whichever comes first, and prior to April 1, Reclamation and DWR propose to manage exports in order to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. The purpose of this action is to protect Delta Smelt from damaging levels of entrainment after a First Flush and in years when a First Flush does not occur. This action seeks to avoid the formation of a continuous turbidity bridge from the San Joaquin River shipping channel to the fish facilities, which historically has been associated with elevated salvage of prespawning adult Delta Smelt. If the day daily average turbidity at Bacon Island cannot be maintained less than 12 NTU, Reclamation and DWR will manage exports to achieve an OMR no more negative than -2,000 cfs until the turbidity at Bacon Island drops below 12 NTU. After 5 days, Reclamation and DWR may determine that additional real-time OMR restrictions are not required to avoid damaging levels of entrainment based on the

- distribution of Delta Smelt in real-time monitoring and the absence of detections in salvage (i.e. <5% of the population).
- Larval and Juvenile Delta Smelt: When Q-West is negative and larval or juvenile Delta Smelt are within the entrainment zone of the pumps based on real-time sampling, Reclamation and/or DWR propose to run hydrodynamic models informed by the EDSM, 20 mm or other relevant survey data to estimate the percentage of larval and juvenile Delta Smelt that could be entrained and operate to avoid greater than 10 percent loss of modeled larval and juvenile cohort Delta Smelt (typically this would come into effect beginning the middle of March).

• Cumulative Loss Threshold:

- Reclamation and DWR propose to avoid exceeding cumulative loss thresholds over the duration of the Biological Opinions for wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April 1 through June 15th. Wild Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.
- O The cumulative loss thresholds shall be based on cumulative historical loss from 2010 through 2018. Reclamation's and DWR's performance objectives will set a trajectory such that this cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.
- O If, at any time prior to 2024, Reclamation and DWR exceed 50% of the cumulative loss threshold, Reclamation and DWR will convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.
- In the year 2024, Reclamation and DWR will convene an independent panel to review the first five years of actions and determine whether continuing these actions are likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.
- O If, during real-time operations, Reclamation and DWR exceed the cumulative loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR shall, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of this Proposed Action. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow

measures to improve survival in the south Delta and for San Joaquin origin fish.

Single-Year Loss Threshold:

- o In each year, Reclamation and DWR propose to avoid exceeding an annual loss threshold equal to 90% of the greatest annual loss that occurred in the historical record from 2010 through 2018 for each of wild Winter-Run Chinook Salmon, hatchery Winter-Run Chinook Salmon, wild Central Valley Steelhead from December through March, and wild Central Valley Steelhead from April through June 15. Wild Central Valley Steelhead are separated into two time periods to protect San Joaquin Origin fish that historically appear in the Mossdale trawls later than Sacramento origin fish. The loss threshold and loss tracking for hatchery Winter-Run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook salmon are based on length-at-date criteria.
- Ouring the year, if Reclamation and DWR exceed the average annual loss from 2010 through 2018, Reclamation and DWR will review recent fish distribution information and operations with the fisheries agencies at WOMT and seek technical assistance on future planned operations. Any agency may elevate from WOMT to a Directors discussion, as appropriate.
- Ouring the year, if Reclamation and DWR exceed 50% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR index of no more negative than -3,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.
- The -3500 OMR operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations.
- Ouring the year, if Reclamation and DWR exceed 75% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR index of no more negative than -2,500 cfs, unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.
- The -2500 OMR operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. Reclamation and DWR will seek NMFS technical assistance on the risk assessment and real-time operations.
- Risk assessment: Reclamation and DWR will determine and adjust OMR restrictions under this section by preparing a risk assessment that considers several factors including, but not limited to, real-time monitoring detects few fish in the south Delta and few fish are detected in salvage. Reclamation and DWR will share its technical analysis and supporting documentation with USFWS and NMFS, seek their technical assistance, discuss the risk assessment

- and future operations with WOMT at its next meeting, and elevate to the Directors as appropriate.
- o If, during real-time operations, Reclamation and DWR exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from USFWS and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR shall, prior to the next OMR management season, charter an independent panel to review the OMR Management Action consistent with "Chartering of Independent Panels" under the "Governance" section of this Proposed Action. The purpose of the independent review shall be to evaluate the efficacy of actions to reduce the adverse effects on listed species under OMR management and the non-flow measures to improve survival in the south Delta and for San Joaquin origin fish.
- Reclamation and DWR shall consider the historical monthly distribution of loss to avoid disproportionately salvaging fish during any single month.

Reclamation and DWR propose to continue monitoring and reporting the salvage at the Tracy Fish Collection Facility and Skinner Delta Fish Protection Facility. Reclamation and DWR propose to continue the release and monitoring of yearling Coleman NFH late-fall run as yearling Spring-Run Chinook Salmon surrogates."

Storm-Related OMR Flexibility:

"Reclamation and DWR may operate to a more negative OMR up to a maximum (otherwise permitted) export rate at Banks and Jones Pumping Plants of 14,900 cfs (which could result in a range of OMR values) to capture peak flows during storm-related events. Reclamation and DWR will continue to monitor fish in real-time and will operate in accordance with "Additional Real-time OMR Restrictions," above. *Under the following conditions, Reclamation and DWR would not cause OMR to be more negative for capturing peak flows from storm-related events if:*

- Integrated Early Winter Pulse Protection (above) or Additional real-time OMR restrictions (above) are triggered. Under such conditions, Reclamation and DWR have already determined that more restrictive OMR is required.
- An evaluation of environmental and biological conditions indicates more negative OMR would likely cause Reclamation and DWR to trigger an Additional real-time OMR restriction (above).
- Salvage of yearling Coleman NFH latefall run as yearling Spring-Run Chinook Salmon surrogates exceeds 0.5% within any of the release groups.
- Reclamation and DWR identify changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those described in the forthcoming biological opinion for this project.

Reclamation and DWR will continue to monitor conditions may resume management of OMR to no more negative than -5,000 cfs if conditions indicate the above offramps are necessary to avoid additional adverse effects. If storm-related flexibility causes the conditions in "Additional Real-Time OMR Restrictions", Reclamation and DWR will implement additional real-time OMR restrictions."

End of OMR Management:

"OMR criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), *until June 15 (for steelhead/rainbow trout)*, or when the following species-specific off ramps have occurred, whichever is earlier:

- Delta Smelt: when the daily mean water temperature at CCF reaches 25°C for 3 consecutive days;
- Salmonids:
 - o when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or
 - o after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive)."

Real-Time Decision Making and Salvage Thresholds

"Reclamation and DWR may confer with the Directors of NMFS, USFWS, and CDFW if they desire to operate to a more negative OMR than what is specified in "Additional Real-Time OMR Restrictions." Upon mutual agreement, the Directors of NMFS and USFWS may authorize Reclamation to operate to a more negative OMR. than the "Additional Real-Time OMR Restrictions", but no more negative than -5000 cfs. The Director of CDFW may authorize DWR to operate to a more negative OMR. than the "Additional Real-Time OMR Restrictions", but no more negative than -5000 cfs."

The key changes in the OMR management component of the June 14, 2019 final PA in comparison to the February 5, 2019, PA are summarized in Table 2.5.5-71.

The specific cumulative and single-year loss thresholds are described in detail in Appendix J and summary figures are provided showing historical loss and associated loss thresholds for wild winter-run Chinook salmon (Figure 2.5.5-34), hatchery winter-run Chinook salmon (

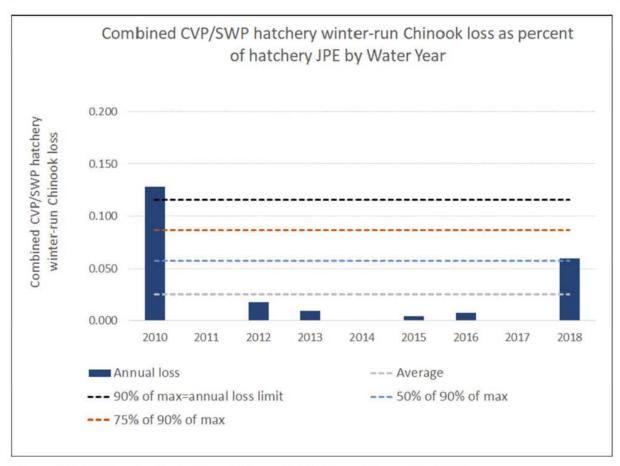


Figure 2.5.5-35) and wild steelhead (Figure 2.5.5-36 and Figure 2.5.5-37).

2.5.5.11.1.1 Assess Effects to Species of Revisions to OMR Management

2.5.5.11.1.1.1 Assess Exposure to Species from Revised OMR Management

The revised OMR management component in the final PA (and any associated changes in exports) will not affect overall seasonal presence of listed salmonids and sDPS green sturgeon in the Delta. To the extent that changes in OMR management under the final PA may change distribution of fish within the south Delta, fish may be more (if OMR more negative) or less (if OMR more positive) vulnerable to entrainment into and loss at the south Delta export facilities.

There is interannual variability in loss rates observed for wild and hatchery winter-run Chinook salmon, and wild CCV steelhead (see Figure 2.5.5-34 through Figure 2.5.5-37). Some of this variability is likely due to interannual variability in population size, but note that variability is observed even for wild winter-run Chinook salmon after scaling to estimated population size (Figure 2.5.5-34). Other sources of variability that may influence loss rates include juvenile survival to the Delta, the fraction of juveniles that route into the south Delta where fish are vulnerable to entrainment, hydrologic conditions, and operations. The mix of single-year and long-term cumulative thresholds is designed to accommodate this interannual variability while controlling for long-term loss.

2.5.5.11.1.1.2 Assess Response to Species from Revised OMR Management

NMFS's approach to linking hydrodynamics with species responses is described earlier in the Delta effects section. So, to understand the species responses, NMFS first assesses the likely difference in hydrodynamic conditions under the final PA compared to the original PA. It is uncertain how exactly exports and OMR flows under the final PA will change in a given month and year type compared to the original PA, but NMFS makes the following assumptions for this supplemental analysis.

- The changes to the turbidity-related OMR triggers likely have little to no effect on our analysis, since the OMR limits in the final PA are consistent with the modeling assumptions used for the modeling provided with the original BA.
- The removal of the 10 steelhead/TAF loss trigger may reduce the frequency of short-term "pulse protection" at a -2,500 cfs OMR limit for steelhead, but in our original analysis (in the previous sections), NMFS expressed concern that this protective action would rarely be triggered, so the loss of a rarely-triggered protective action does not substantively change our analysis.
- Based on discussion among the Federal directors, NMFS understands that the average
 historical loss threshold is a "yellow light" to discuss and manage future operations; the
 other interim loss thresholds (50 percent and 75 percent of the annual loss limit of 90
 percent of maximum historical loss) are also "yellow lights" that are associated with even
 more formal risk assessment and discussion.
- The cumulative and single-year loss thresholds are lower in the final PA, and thus the
 interim thresholds at 50 percent and 75 percent of the annual loss threshold are more
 likely to be reached and a potential OMR action response considered.
- When 50 percent or 75 percent of a loss threshold is reached, operations under the final PA are less certain to result in a more positive OMR than under the original PA. While the action response in the final PA is contingent on the conclusion of Reclamation's and DWR's risk assessment, the action response will occur "unless Reclamation and DWR determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information." Additionally, the risk assessment will undergo inter-agency review, since "Reclamation and DWR will share its technical analysis and supporting documentation with USFWS and NMFS, seek their technical assistance, discuss the risk assessment and future operations with WOMT at its next meeting, and elevate to the Directors as appropriate." So, while it is not certain whether OMR limits more positive than -5,000 cfs are more or less likely under the final PA, the multiple process steps in the final PA provide some assurance that species risks will be conservatively managed.
- Change in the date-based offramp criterion for steelhead from June 30 to June 15 means
 that, if OMR management is not in effect for another species, OMR management might
 end up to two weeks sooner for steelhead, potentially exposing steelhead migrating
 through the Delta in late June to hydrodynamic conditions less suited for successful
 outmigration.

2.5.5.11.1.1.3 Assess Risk to Species from Revised OMR Management

The cumulative and single-year loss thresholds were developed to limit loss for key (and reliably measurable) populations to loss rates observed under implementation of the NMFS 2009 Opinion. The intent of these PA revisions was to limit direct loss at the south Delta export facilities as a way to limit some of the higher-magnitude effects under the original PA – specifically, effects associated with DCC operations, OMR Storm Flexibility, and increased exports in April and May. The concept was that, rather than use the hydrodynamic metric of OMR to manage species risks, we could use a metric of historical loss rates to keep risks comparable to risks under the NMFS 2009 Opinion. NMFS concludes that this approach is a reasonable way to limit risks associated with the near-field effects (entrainment into and loss at) the export facilities. While there are some uncertainties in how this new approach will be implemented, the final PA includes triggers for review and technical assistance anytime observed loss exceeds average annual historical loss, which provide some assurance that species risks will be conservatively managed. While loss is still expected to occur under the final PA, NMFS notes that the loss thresholds are expected to limit loss to levels less than estimated using the Salvage Density Model results described in Section 2.5.5.8.3.1, and to levels comparable to loss observed under the COS. The Salvage Density Model showed the greatest differences in the PA vs. the COS during April and May, and NMFS expects that the benefits of the revised loss thresholds (relative to the original PA) will be greatest during this April-May period during outmigration of CCV steelhead (particularly from the San Joaquin basin) and young-of-year CV spring-run Chinook salmon.

It is less certain whether this approach will fully limit risks associated with the far-field effects (potential disruptions to migration rate or route) of the export facilities. Because NMFS assumes that far-field effects are correlated with exports (both footprint and magnitude of hydrodynamic effect greater at higher exports), limiting near-field effects to historical rates could be assumed to limit far-field effects to historic rates. However, it is likely that OMR (and associated Delta hydrodynamics) may still be more negative under the final PA than observed under the COS, especially in April and May. Under the COS, the OMR exceedance plots show that OMR is positive for approximately 50% of years, yet under the final PA, the most-restrictive OMR limit (which is not guaranteed to be implemented) is -2,500 cfs. NMFS does acknowledge that, especially in drier years, other factors may control OMR and lead to OMR flows more positive than the OMR limits associated with the loss thresholds of the final PA. For example, the modeling even for the original BA showed that April and May OMR flows under the original PA during critical years were about -1,500 cfs.

2.5.5.11.2 Assess effects to species of additional conservation measures

2.5.5.11.2.1 Address scour hole at Head of Old River

2.5.5.11.2.1.1 Deconstruct the Action for the scour hole at the Head of Old River

The final PA describes this action as follows:

• "Reclamation and DWR would form a project team to address the scour hole in the San Joaquin River at the Head of Old River. The project team would plan and implement

measures to reduce the predation intensity at that site through modifications to the channel geometry and associated habitats."

2.5.5.11.2.1.2 Assess species exposure, response, and risk

Reducing predation at the scour hole in the San Joaquin River at the Head of Old River is a specific example of the conservation measure in the original PA to "remove predator hot spots in the Bay-Delta", described in Section 2.5.5.10.5.2. The effects are expected to be as described there, with benefits most likely accruing to CCV steelhead and CV spring-run Chinook salmon entering the Delta from the San Joaquin River. As for the overall measure to address predator hot spots, this PA component will be considered as a programmatic consultation.

2.5.5.11.2.2 Delta Cross Channel operations

2.5.5.11.2.2.1 Deconstruct the Action for the DCC operations

The PA revisions associated with DCC operations clarified that December through January DCC openings would be limited to occasions when drought conditions are observed (defined as 90 percent exceedance hydrology) and gate opening will help to address water quality concerns -- for a joint probability of less than 10 percent. The final PA also includes a new commitment to reduce combined CVP/SWP exports to health and safety levels (NMFS assumes that this is 1,500 cfs) during any DCC gate opening in December or January.

2.5.5.11.2.2.2 Assess species exposure, response, and risk

During December and January, a substantial proportion of the juvenile winter-run Chinook salmon cohort may be at risk of entrainment into the DCC, but that additional risk, relative to under COS conditions, is expected to be realized in less than 10 percent of years. Because these DCC revisions to the PA were provided to NMFS earlier than other revisions, the effects are already analyzed in the primary effects section.

2.5.5.11.2.3 Steelhead Lifecycle Monitoring Program and San Joaquin Basin Steelhead Collaborative

2.5.5.11.2.3.1 Deconstruct the Action for the Steelhead Lifecycle Monitoring Program and San Joaquin Basin Steelhead Collaborative

The final PA included the following items:

• Steelhead Lifecycle Monitoring Program: Develop infrastructure that will support a functioning life cycle monitoring program in the Stanislaus River and a Sacramento basin CVP tributary (e.g. Clear Creek, Upper Sacramento, American River) to evaluate how actions related to stream flow enhancement, habitat restoration, and/or water export restrictions affect biological outcomes including population abundance, age structure, growth and smoltification rates, and anadromy and adaptive potential in these populations. The goal of this monitoring program will be to improve understanding of steelhead demographics and, when combined with other steelhead-focused parts of the PA (San Joaquin and Delta steelhead telemetry study), inform actions that will increase steelhead abundance and improve steelhead survival through the Delta.

• San Joaquin Basin Steelhead Collaborative: Within 1 year, Reclamation will coordinate with CSAMP to sponsor a workshop for developing a plan to monitor steelhead populations within the San Joaquin Basin and/or the San Joaquin River downstream of the confluence of the Stanislaus River, including steelhead and rainbow trout on non-project San Joaquin tributaries. The plan would be delivered to the IEP for prioritization and implementation, where feasible, for actions within the responsibility of the CVP and SWP and other members of the IEP. If the IEP is not able to implement the plan, the plan may be raised at the Director Level Collaborative Planning Meeting described under the "Governance" section of this PA for resolution.

2.5.5.11.2.3.2 Assess species exposure, response, and risk

NMFS supports both of these efforts to get better information about CCV steelhead which may inform development of beneficial actions to increase steelhead abundance or survival. NMFS considers both items to be programmatic consultations.

2.5.5.12 Delta Effect Section Figures

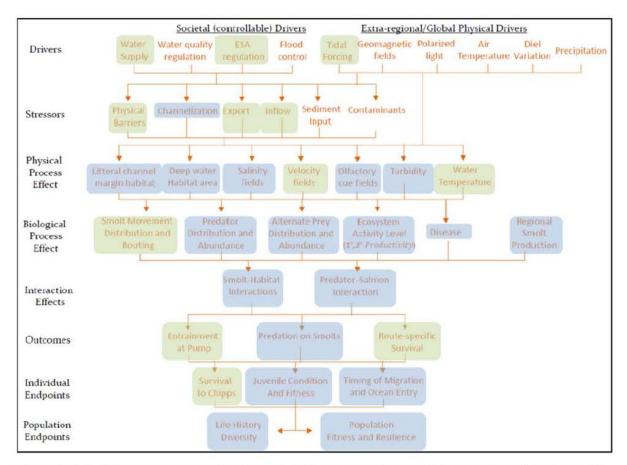


Figure 2.5.5-1. Conceptual model from the South Delta Salmonid Research Collaborative Effort describing factors affecting survival of juvenile salmonids in the South Delta. Green highlights indicate model components included within the narrower scope of the SST report. Blue highlights indicate model components also potentially relevant to export effects and recommended by the SST for inclusion in an expanded research program. [Source: Figure 2-1 of (Salmonid Scoping Team 2017a)]

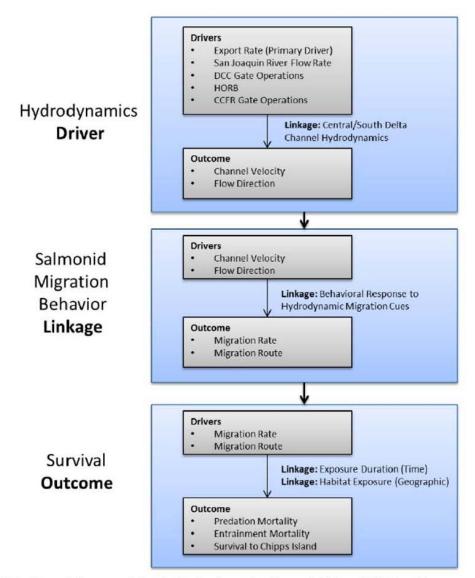


Figure 2.5.5-2. General framework linking hydrodynamic effects of CVP and SWP project operations to migration behavior and survival.

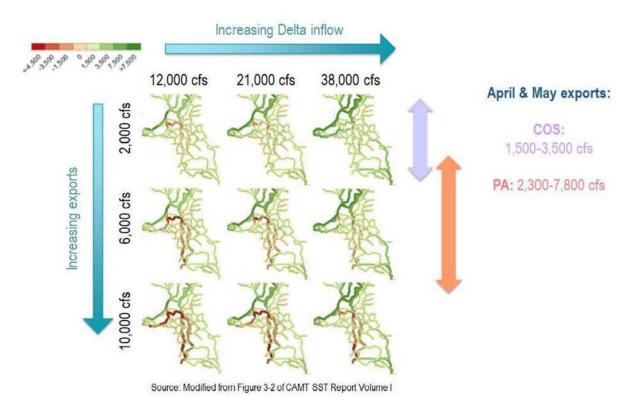


Figure 2.5.5-3. Heatmap of daily average flows in the Delta modeled in DMS2 under nine scenarios cross-factoring three export rates and three Delta inflow rates. Red represents negative (upstream) net flows; green represents positive (downstream) net flows. Export rates were 2,000, 6,000, and 10,000 cfs. Delta inflow rates were 12,000 (10,595 Sacramento River and 1,405 San Joaquin River), 21,000 (18,264 Sacramento River and 2,736 San Joaquin River), and 38,000 cfs (32,288 Sacramento River and 5,712 San Joaquin River). Two-sided arrows indicate the range of modeled monthly exports during April and May for the COS (purple) and the PA (orange). [Source: Modified from Figure 3-2 of (Salmonid Scoping Team 2017a)]

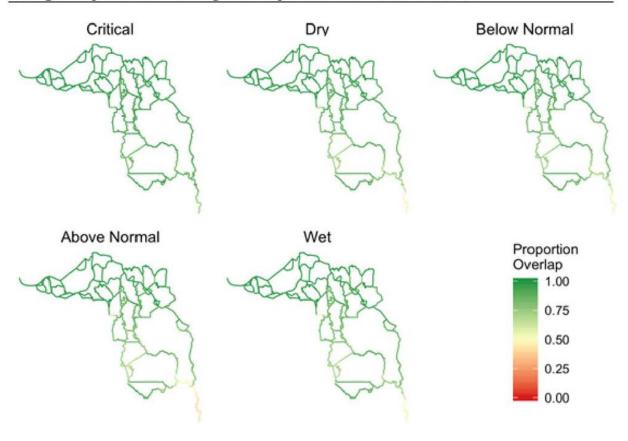


Figure 2.5.5-4. Map of proportion overlap of velocity distributions in the South Delta for the PA and COS scenarios in March through May. [Source: Figure H-9 of Appendix H of ROC LTO BA]

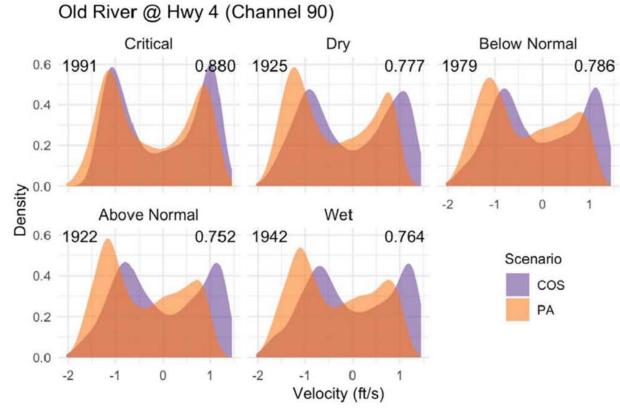


Figure 2.5.5-5. Proportion overlap of velocity distributions in the South Delta (Old River at Highway 4; downstream of the export facilities) for the PA and COS scenarios in March through May. [Source: Supplemental modeling provided in support of ROC LTO BA]

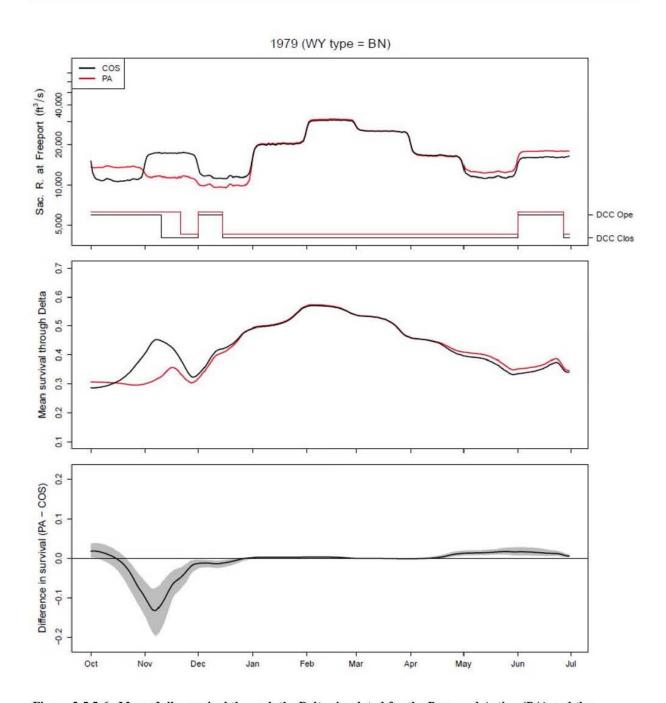


Figure 2.5.5-6. Mean daily survival through the Delta simulated for the Proposed Action (PA) and the Current Operating Scenario (COS) (middle panel) and difference in the mean daily survival between the PA and COS (bottom panel). The top panel shows the flows at Freeport on a logarithmic scale for the two scenarios, as well as the operations of the DCC gates (open or closed).

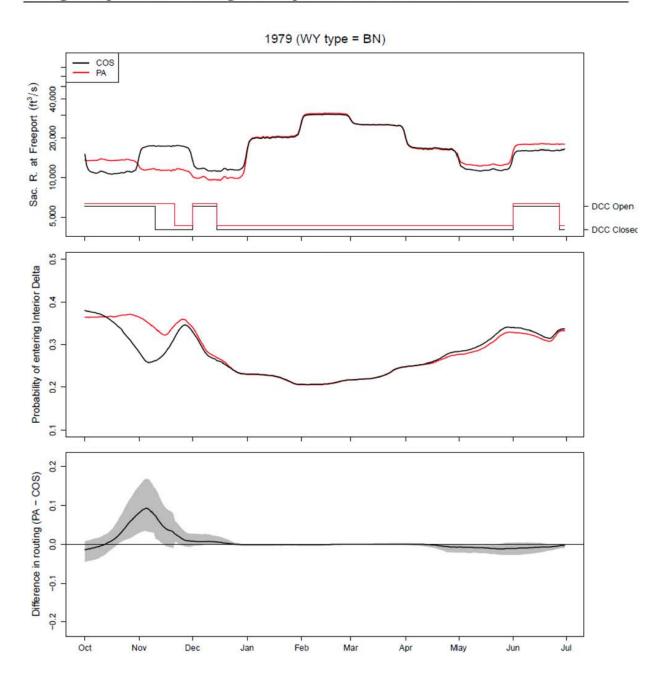


Figure 2.5.5-7. Mean daily probability of entering the interior Delta simulated for the Proposed Action (PA) and the Current Operating Scenario (COS) (middle panel) and difference in the mean daily probability of routing into the interior Delta between the PA and COS (bottom panel). The top panel shows the flows at Freeport on a logarithmic scale for the two scenarios, as well as the operations of the DCC gates (open or closed).

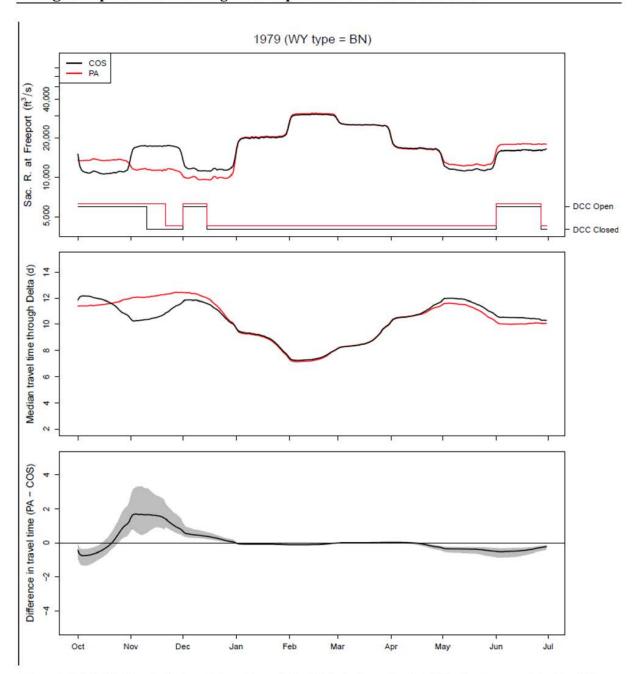


Figure 2.5.5-8. Median daily travel time through the Delta in days simulated for the Proposed Action (PA) and the Current Operating Scenario (COS) (middle panel) and difference in the median travel time through the Delta between the PA and COS (bottom panel). The top panel shows the flows at Freeport on a logarithmic scale for the two scenarios, as well as the operations of the DCC gates (open or closed).

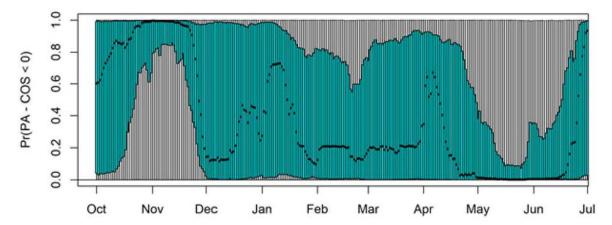


Figure 2.5.5-9. Boxplots showing the distribution of the probability that through-Delta survival for the PA scenario is less than survival for COS. Each box plot represents the distribution among years for a given date of the probability that the difference between PA and COS is less than zero. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

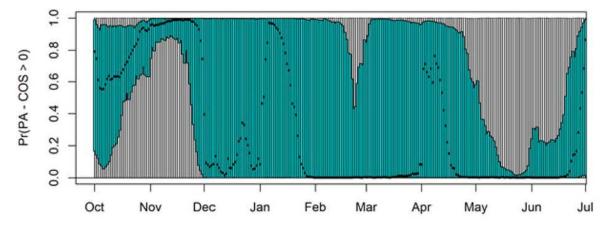


Figure 2.5.5-10. Boxplots showing the distribution of the probability that the difference in median travel time through the Delta between the COS and PA scenario is greater than zero. Each box plot represents the distribution among years for a given date of the probability that the difference between PA and COS is greater than zero. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

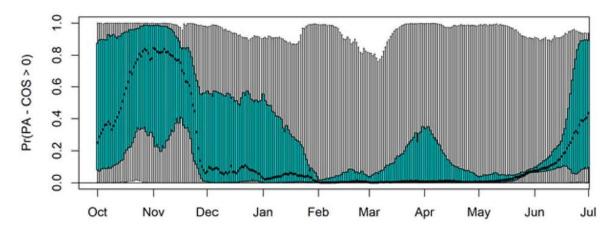


Figure 2.5.5-11. Boxplots showing the distribution of the probability that the difference in routing into the Interior Delta between the COS and PA scenario is greater than zero. Each box plot represents the distribution among years for a given date of the probability that the difference between PA and COS is greater than zero. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

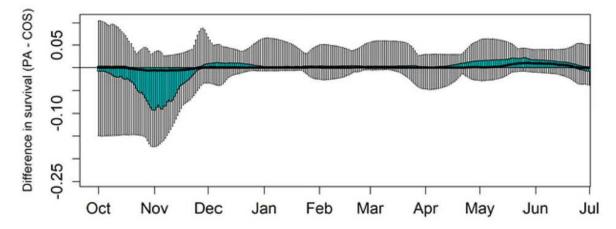


Figure 2.5.5-12. Boxplots of daily median differences in through-Delta survival between the PA and COS scenario. Each box plot represents the distribution of median survival differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

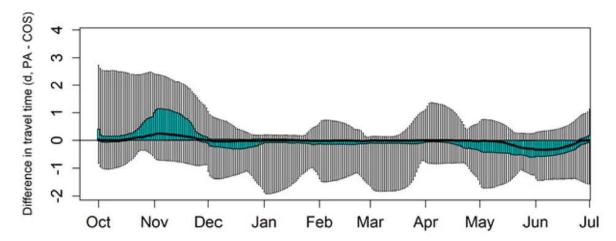


Figure 2.5.5-13. Daily boxplots of median differences in median travel time between the PA and COS scenario. Each box plot represents the distribution of median travel time differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

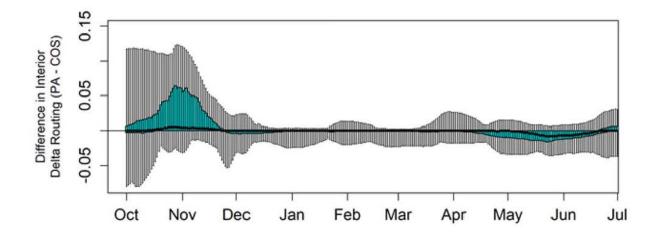


Figure 2.5.5-14. Daily boxplots of median differences in routing to the Interior Delta betwen the PA and COS scenario. Each box plot represents the distribution of median routing differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

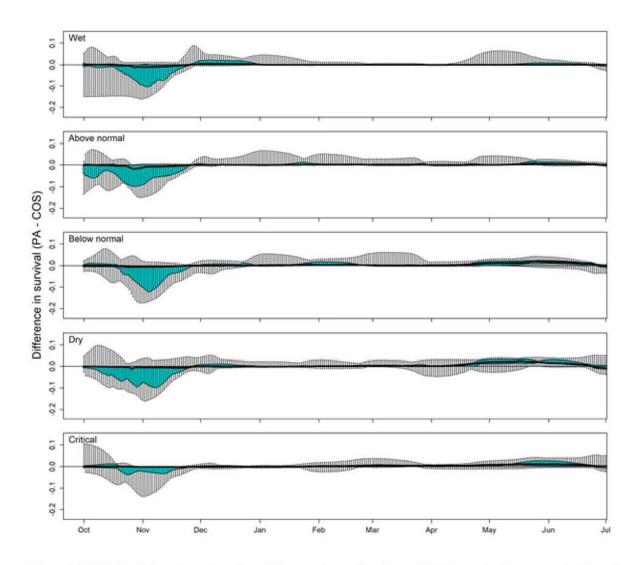


Figure 2.5.5-15. Daily boxplots of median differences in median through-Delta survival between the PA and COS scenario by water year type. Each box plot represents the distribution of median survival differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

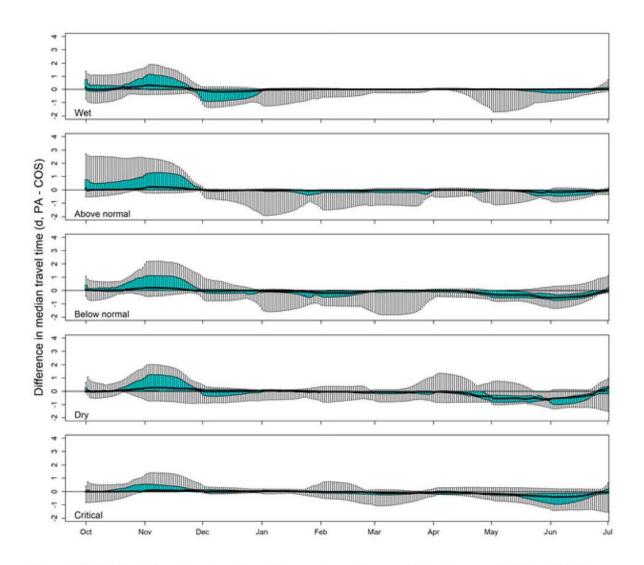


Figure 2.5.5-16. Daily boxplots of median differences in median travel time between the PA and COS scenario by water year type. Each box plot represents the distribution of median travel time differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

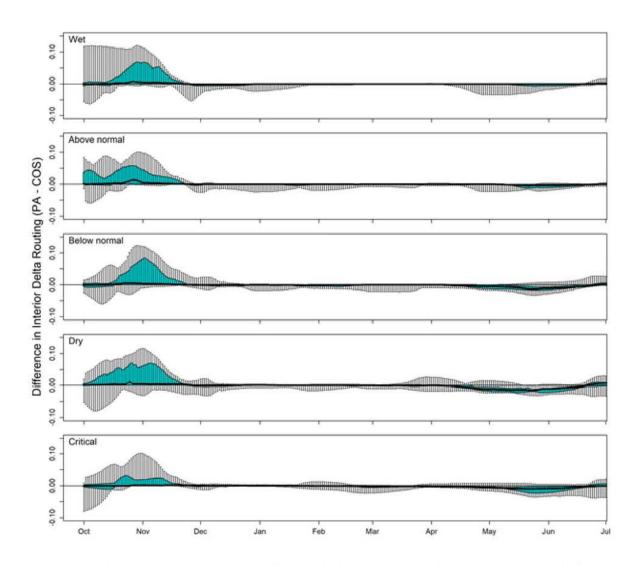


Figure 2.5.5-17. Daily boxplots of median differences in interior Delta routing between the PA and COS scenario by water year type. Each box plot represents the distribution of median routing differences among years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

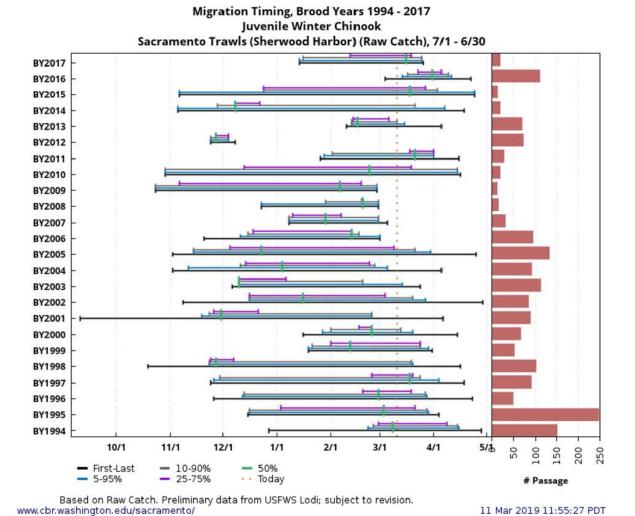


Figure 2.5.5-18. Juvenile winter-run Chinook salmon migration timing past the Sherwood Harbor - Sacramento Trawl location for Brood Years 1994-2017.

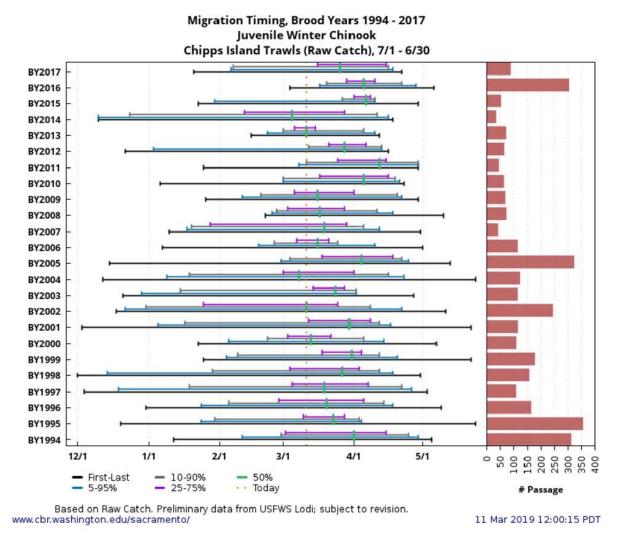


Figure 2.5.5-19. Juvenile winter-run Chinook salmon migration timing past the Chipps Island Trawl location for Brood Years 1994-2017.

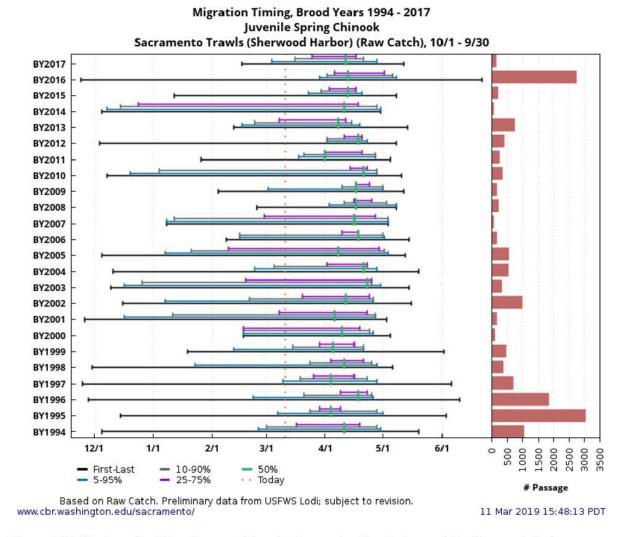


Figure 2.5.5-20. Juvenile CV spring-run Chinook salmon migration timing past the Sherwood Harbor – Sacramento Trawl location for Brood Years 1994-2017.

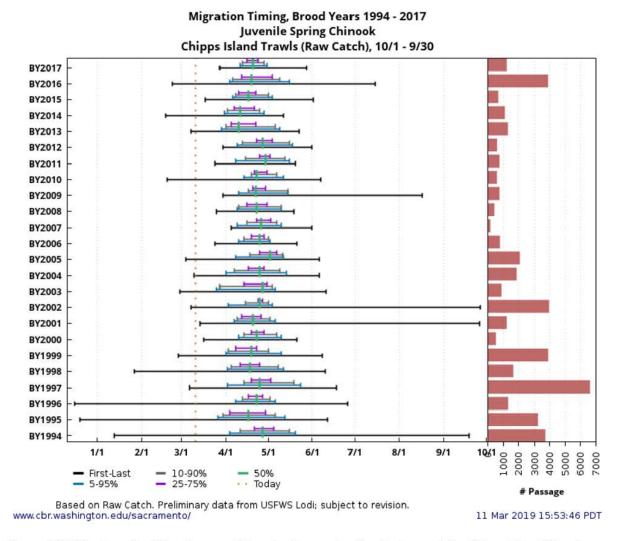


Figure 2.5.5-21. Juvenile CV spring-run Chinook salmon migration timing past the Chipps Island Trawl location for Brood Years 1994-2017.

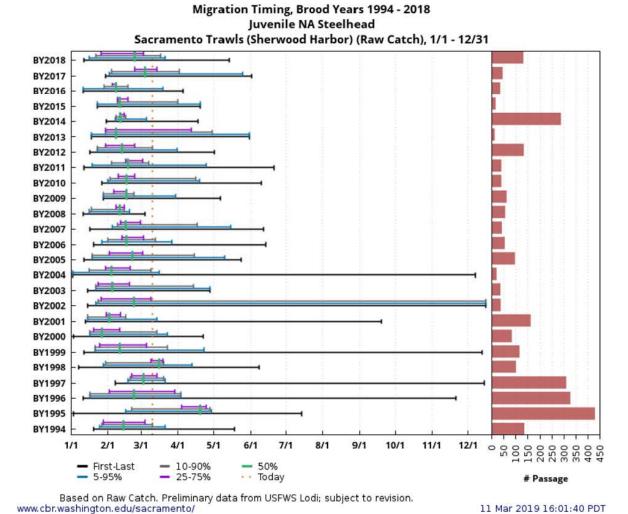


Figure 2.5.5-22. Juvenile unclipped CCV steelhead migration timing past the Sherwood Harbor -Sacramento Trawl location for Brood Years 1994-2017.

www.cbr.washington.edu/sacramento/

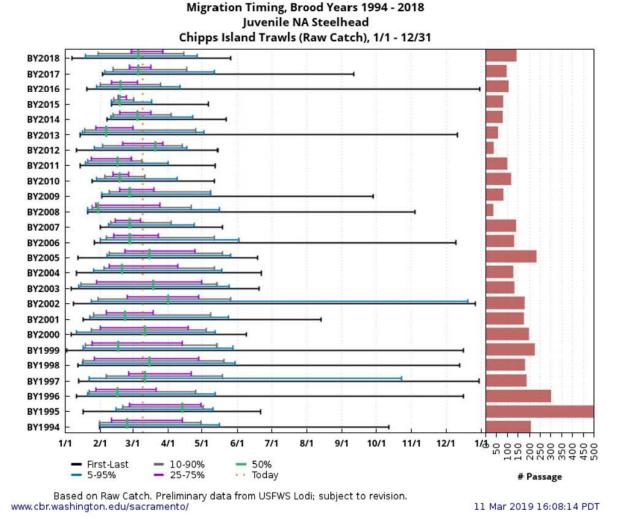


Figure 2.5.5-23. Juvenile unclipped CCV steelhead migration timing past the Chipps Island Trawl location for Brood Years 1994-2017.

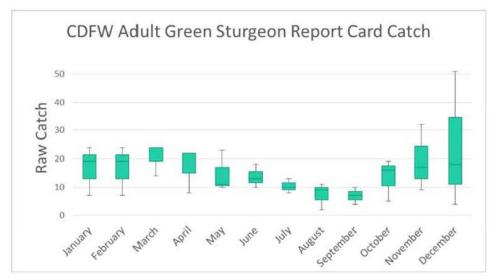


Figure 2.5.5-24. CDFW adult raw catch data for sDPS green sturgeon in the Delta from 2007-2014. The monthly median is marked by a horizontal line splitting each box. The upper and lower whiskers show the maximum and minimum values for each month over all years.

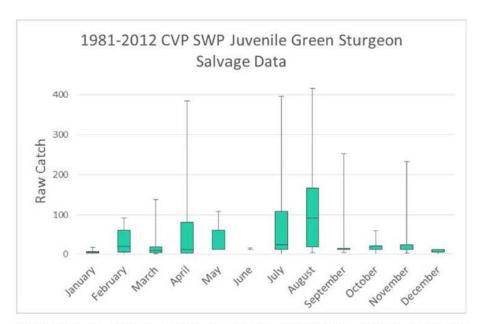


Figure 2.5.5-25. Monthly raw salvage data for juvenile green sturgeon by month at the SWP and CVP fish salvage facilities (1981-2012). The monthly median is marked by a horizontal line splitting each box. The upper and lower whiskers show the maximum and minimum values for each month over all years.

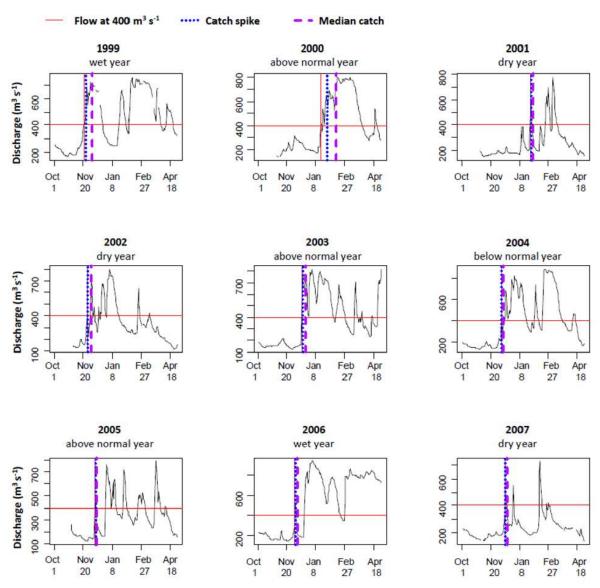


Figure 2.5.5-26. Flow threshold of 400 m3 s-1 triggers abrupt and substantial winter-run migration into the Delta at Knights Landing. The first day that flows reached 400 m3 s-1 (solid vertical line) is nearly coincident with the day of catch spike (increase of 5% of cumulative catch; dotted line) and the day of median catch (50th percentile of cumulative catch; dashed line). Years refer to spring emigration season. [Source: Figure 5 of del Rosario et al. (2013)]

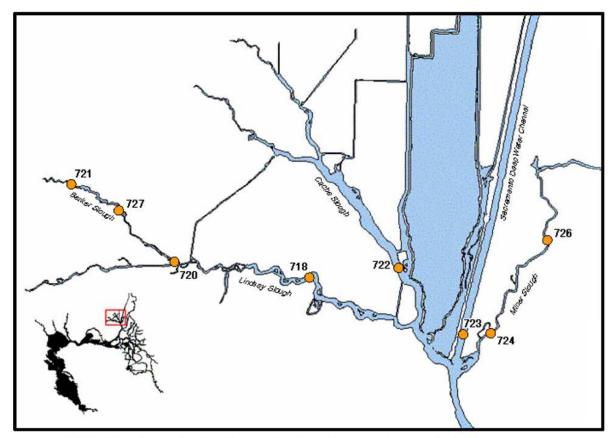


Figure 2.5.5-27. Map of sampling locations for the North Bay Aqueduct monitoring trawls.

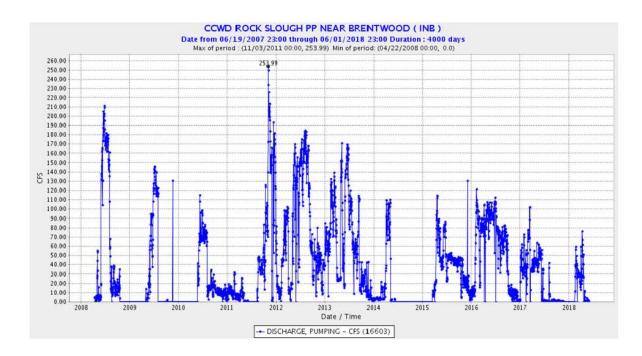


Figure 2.5.5-28. Historical diversion of water through the CCWD Rock Slough Pumping Plants 2008-2019. Available: http://cdec.water.ca.gov/dynamicapp/QueryDaily?s=INB&d=17-Mar-2019+00:00

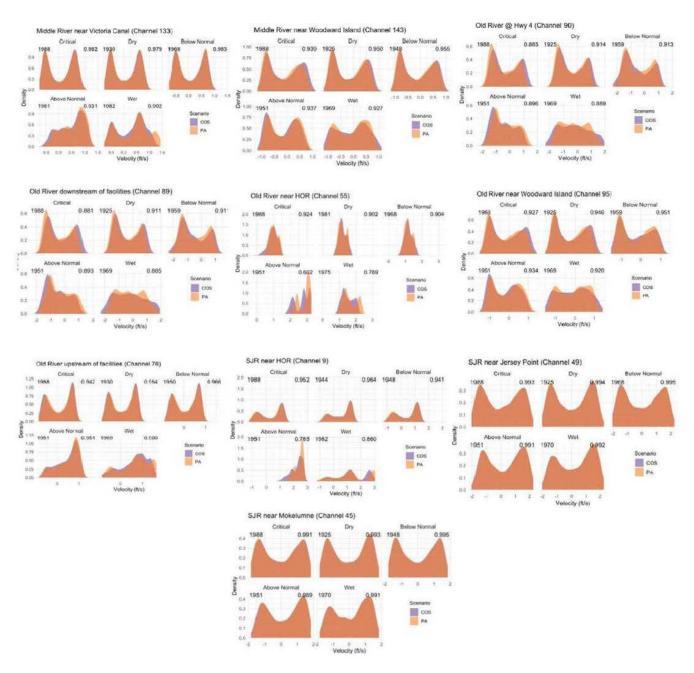


Figure 2.5.5-29. Velocity Density Plots for different locations in the South Delta: Dec - Feb Plots

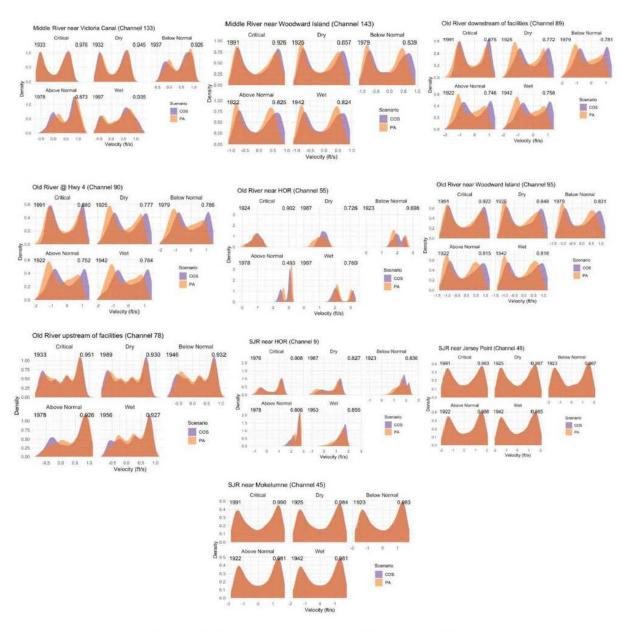


Figure 2.5.5-30. Density Plots for different locations in the South Delta: Mar - May Plots

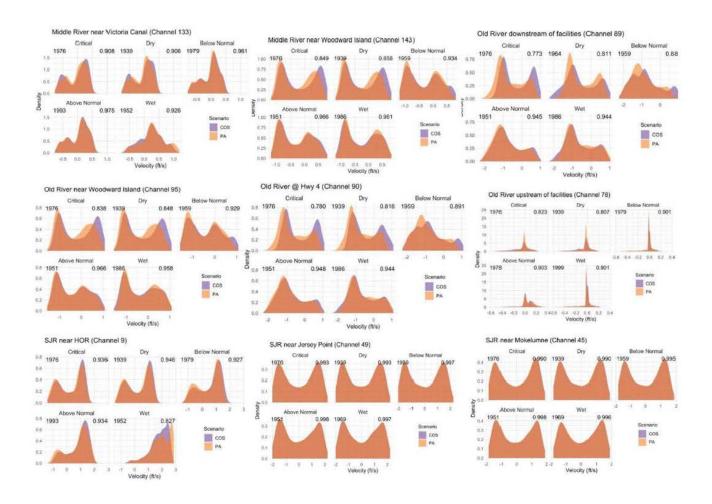


Figure 2.5.5-31. Velocity Density Plots for different locations in the South Delta: Jun - Aug Plots

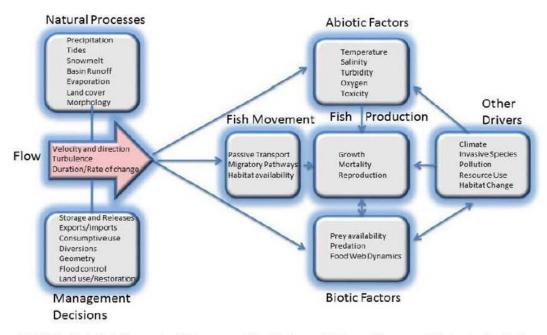


Figure 2.5.5-32. Detailed Conceptual Diagram of the Linkages Between Flows and Fishes in the Delta. (Source: Appendix B from Delta Independent Science Board 2015)

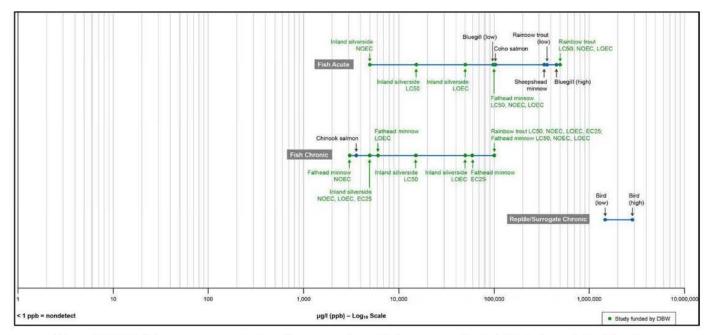


Figure 2.5.5-33. Exposure concentrations for surrogate and fish species endpoint effects for endothall (μg/L or ppb, CDBW 2017)

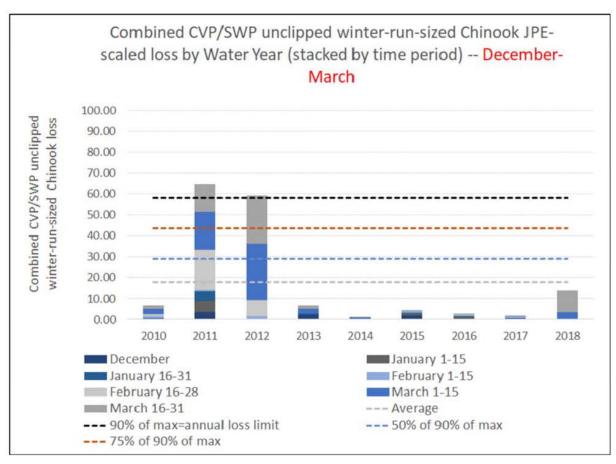


Figure 2.5.5-34. Combined CVP/SWP unclipped winter-run-sized Chinook loss, as a percentage of the winter-run Juvenile Production Estimate (JPE), for WY 2010 through WY 2018. Bars represent cumulative loss from December through March, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for OMR management.

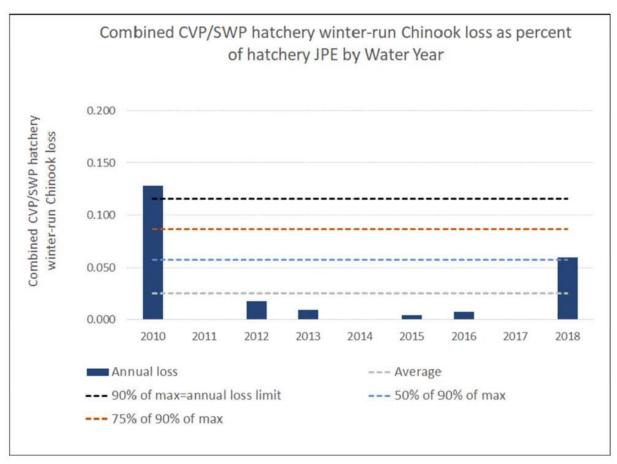


Figure 2.5.5-35. Combined CVP/SWP hatchery winter-run Chinook loss for WY 2010 through WY 2018, as a percent of the number released into the Sacramento River. Bars represent cumulative loss observed within the water year of release. Horizontal reference lines indicate the loss thresholds relevant for OMR management.

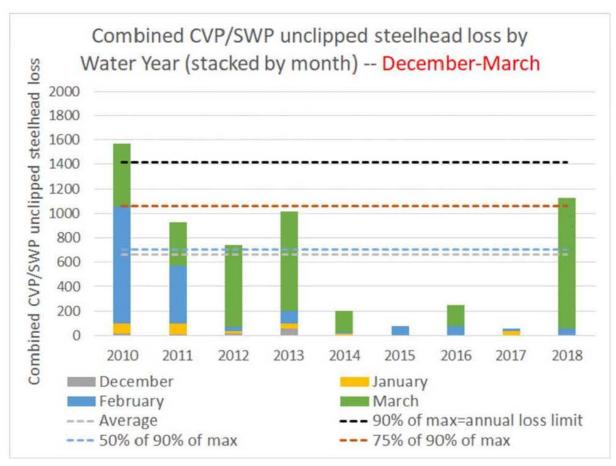


Figure 2.5.5-36. Combined CVP/SWP wild steelhead loss for WY 2010 through WY 2018. Bars represent cumulative loss from December through March, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for OMR management.

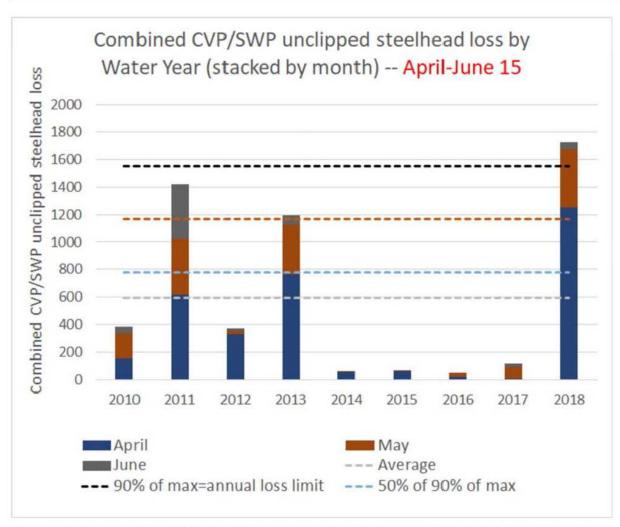


Figure 2.5.5-37. Combined CVP/SWP wild steelhead loss for WY 2010 through WY 2018. Bars represent cumulative loss from April through June 15, stacked by month. Horizontal reference lines indicate the loss thresholds relevant for OMR management.

2.5.5.13 Delta Effects Section Tables

Table 2.5.5-2. Driver-linkage-outcomes analyzed in SST 2017 related to Hydrodynamics. [Source: Table 2-1 of SST 2017a]

Drivers	Linkages	Outcomes		
 Exports River inflow (Sacramento and San Joaquin) Tide Channel morphology 	 Proximity to exports Channel configuration/barrier deployment Clifton Court Forebay (CCF) operation radial gate operations (e.g., opening to fill CCF and then closing to isolate the pumping plant operations from the Delta) 	 Instantaneous velocities or flows Net daily flow Sub-daily velocity Percent positive flow Water temperature Salinity Residence time Source/origin of water 		

Note: Red italicized text indicates DLOs that were not included in the analysis.

Table 2.5.5-3. Driver-linkage-outcomes analyzed in SST 2017 related to Behavior. [Source: Table 2-2 of SST 2017a]

Drivers	Linkages	Outcomes
 Instantaneous flow/velocity (channels) Instantaneous flow/velocity (junctions) Water quality (e.g., temperature, dissolved oxygen, salinity, turbidity, contaminants Hydraulic residence time Spatial/temporal heterogeneity of hydrodynamic/water quality drivers Small-scale hydrodynamics as affected by structures/bathymetry 	Physiological and behavioral responses to hydrodynamic or water quality conditions, gradients, or variability, such as: Rearing Active swimming Lateral distribution in the channel Passive displacement Diel movements Energy expenditure Selective tidal stream transport	Individual outcomes: Migration rate Migration route Migration timing Timing of Delta entry Delta residence time Rearing location Population outcomes: Population-scale outcomes depend on the spatial/temporal heterogeneity of individual outcomes

Note: Red italicized text indicates DLOs that were not included in the analysis.

Table 2.5.5-4. Driver-linkage-outcomes analyzed in SST 2017 related to salmonid survival. [Source: Table 2-3 of SST 2017a]

Drivers	Linkages	Outcomes	
 Migration route selection Migration rate 	Exposure to variables (e.g., habitat and predators) that affect differential survival between routes or between years for the same route Duration of exposure to route-specific conditions that affect survival	Mortality	

Table 2.5.5-5. Temporal occurrence of winter-run Chinook salmon in the Delta with darker shades indicating months of high presence and lighter shades indicating months of low presence.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult WR ¹												
Juvenile WR ²												
Salvaged WR ³												
		HIGH			MED			LOW			NONE	

¹Adults enter the Bay November to June (Hallock and Fisher 1985) and are in spawning ground at a peak time of June to July (Vogel and Marine 1991).

Table 2.5.5-6. Temporal occurrence of CV spring-run Chinook salmon in the Delta with darker shades indicating months of high presence and lighter shades indicating months of low presence.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult SR1												
uvenile SR ²												
alvaged SR ³												
Salvaged SR ³												
		HIGH			MED			LOW			NONE	

¹Adults enter the Bay late January to early February (CDFW 1998) and enter the Sacramento River in March (Yoshiyama et al. 1998). Adults travel to tributaries as late as July (Lindley et al. 2004). Spawning occurs September to October (Moyle 2002).

²Juvenile presence in the Delta was determined using DJFMP data.

³Months in which salvage of wild juvenile winter-run at State and Federal pumping plants occurred (NMFS 2016)

²Juvenile presence in the Delta based on DJFMP data.

³Juvenile presence in the Delta based on salvage data (NMFS 2016).

Table 2.5.5-7. Temporal occurrence of CCV steelhead in the Delta with darker shades indicating months of high presence and lighter shades indicating months of low presence.

¹Adult presence was determined using information in Moyle (2002), Hallock et al. (1961), and (California Department of Fish and Wildlife 2015b).

Table 2.5.5-8. Temporal occurrence of sDPS green sturgeon in the Delta with darker shades indicating months of high presence and lighter shades indicating months of low presence.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
*Adult GS ¹	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED
*Juvenile GS ²	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED	MED
Salvaged GS ³	LOW	LOW	LOW	LOW	LOW	NONE	MED	HIGH	LOW	LOW	LOW	LOW
	HIGH	HIGH		MED	MED		LOW	LOW		NONE	NONE	

¹Adult presence was determined to be year round according to information in CDFW 2008-2014, Lindley et al. (2004), and Moyle (2002).

Table 2.5.5-9. Delta Cross Channel October 1-November 30 Proposed Action Component

Date	Action Triggers	Action Responses
October 1– November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index or Sacramento Catch Index is greater than five fish per day	Within 48 hours, close the DCC gates and keep closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites
October 1– November 30	Water quality criteria per D-1641 are met, either Knights Landing Catch Index or the Sacramento Catch Index are greater than three fish per day but less than or equal to five fish per day	Within 48 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days
October 1– November 30	Water quality criteria per D-1641 are met, real-time hydrodynamic and salinity modeling shows water quality concern level targets are not exceeded during	Within 48 hours of start of Lower Mokelumne River attraction flow release, close the DCC gates for up

²Juvenile presence in the Delta was determined using DJFMP data.

³Months in which salvage of wild juvenile steelhead at State and Federal pumping plants occurred; values in cells are salvage data reported by the facilities (He and Stuart 2016).

²Juvenile presence in the Delta was determined to be year round by using information in (USFWS DJFMP data), Moyle et al. (1995), and Radtke (1966).

Date	Action Triggers	Action Responses
	28-day period following DCC closure and there is no observed deterioration of interior Delta water quality	to 5 days (dependent upon continuity of favorable water quality conditions)
October 1– November 30	Water quality criteria per D-1641 are met, real time hydrodynamic and salinity modeling shows water quality concern level targets are exceeded during 14-day period following DCC closure	No closure of DCC gates
October 1– November 30	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria	Monitoring groups review monitoring data and provide to Reclamation. Reclamation and DWR determine what to do with a risk assessment

Table 2.5.5-10. Water Quality Concern Level Targets (Water Quality Model simulated 14-day average Electrical Conductivity) Proposed for the Opening of the DCC Gates to Alleviate Water Quality Concerns in the Delta Interior.

Location	Electrical Conductivity
Jersey Point	1800 umhos/cm
Bethel Island	1000 umhos/cm
Holland Cut	800 umhos/cm
Bacon Island	700 umhos/cm

Table 2.5.5-11. Timing of juvenile winter-run Chinook salmon passage past Sherwood Harbor (Sacramento Trawl) for Brood Years 1994 – 2017 (Source: SacPas. Available at: http://www.cbr.washington.edu/sacramento/tmp/hrt 1552451186 673.html).

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
Average (1994-17)	5-Dec	17-Dec	24-Dec	9-Jan	1-Feb	20-Feb	12-Mar	17-Mar	31-Mar
Median (1994-17)	25-Nov	11-Dec	15-Dec	29-Dec	13-Feb	4-Mar	19-Mar	25-Mar	9-Apr
2017	1/13/18	1/13/18	1/15/18	2/11/18	3/15/18	3/18/18	3/24/18	3/24/18	3/25/18
2016	3/3/17	3/13/17	3/16/17	3/22/17	3/30/17	4/4/17	4/8/17	4/10/17	4/21/17
2015	11/6/15	11/6/15	12/24/15	12/24/15	3/16/16	3/25/16	4/1/16	4/22/16	4/22/16
2014	11/5/14	11/5/14	11/28/14	12/8/14	12/8/14	12/22/14	3/20/15	4/6/15	4/17/15
2013	2/9/14	2/12/14	2/12/14	2/13/14	2/15/14	3/5/14	3/10/14	3/14/14	4/4/14
2012	11/23/12	11/23/12	11/23/12	11/26/12	11/26/12	12/3/12	12/3/12	12/3/12	12/7/12
2011	1/25/12	1/27/12	2/1/12	3/16/12	3/19/12	3/30/12	3/30/12	3/30/12	4/13/12
2010	10/29/10	10/29/10	10/29/10	12/13/10	2/22/11	3/18/11	4/13/11	4/13/11	4/15/11
2009	10/23/09	10/23/09	10/23/09	11/6/09	2/5/10	2/17/10	2/26/10	2/26/10	2/26/10
2008	12/22/08	12/22/08	1/28/09	2/17/09	2/18/09	2/18/09	2/27/09	2/27/09	2/27/09
2007	1/7/08	1/7/08	1/7/08	1/9/08	1/28/08	2/6/08	2/27/08	2/27/08	3/3/08

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
2006	11/20/06	12/11/06	12/15/06	12/18/06	2/12/07	2/12/07	2/16/07	2/28/07	2/28/07
2005	11/2/05	11/14/05	11/14/05	12/5/05	12/23/05	3/8/06	3/20/06	3/29/06	4/24/06
2004	11/1/04	11/10/04	12/10/04	12/13/04	1/3/05	2/22/05	2/25/05	3/4/05	4/4/05
2003	12/6/03	12/10/03	12/10/03	12/10/03	12/10/03	1/5/04	2/18/04	3/12/04	3/22/04
2002	11/8/02	12/16/02	12/16/02	12/16/02	1/15/03	3/3/03	3/19/03	3/26/03	4/28/03
2001	9/10/01	11/19/01	11/23/01	11/26/01	11/30/01	12/21/01	2/23/02	2/23/02	4/5/02
2000	1/15/01	1/26/01	1/31/01	2/16/01	2/23/01	2/23/01	3/12/01	3/19/01	4/13/01
1999	1/18/00	1/18/00	1/20/00	1/31/00	2/11/00	3/22/00	3/22/00	3/27/00	3/29/00
1998	10/19/98	11/23/98	11/23/98	11/24/98	11/27/98	12/7/98	3/18/99	3/19/99	4/15/99
1997	11/24/97	11/26/97	11/29/97	2/23/98	3/17/98	3/19/98	3/23/98	4/3/98	4/17/98
1996	11/25/96	12/11/96	12/12/96	2/18/97	2/27/97	3/18/97	3/26/97	3/27/97	4/22/97
1995	12/15/95	12/16/95	12/16/95	1/2/96	3/1/96	3/19/96	3/26/96	3/27/96	4/2/96
1994	12/27/94	2/21/95	2/24/95	2/27/95	3/7/95	4/7/95	4/13/95	4/14/95	4/27/95

Table 2.5.5-12. Timing of juvenile CV spring-run Chinook salmon passage past Sherwood Harbor (Sacramento Trawl) for Brood Years 1994 – 2017 (Source: SacPas. Available at: http://www.cbr.washington.edu/sacramento/tmp/hrt 1552495104 288.html).

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
Average (1994 - 2017)	29-Dec	10-Feb	25-Feb	19-Mar	11-Apr	19-Apr	25-Apr	27-Apr	15-May
Median (1994 - 2017)	13-Dec	18-Feb	9-Mar	28-Mar	11-Apr	19-Apr	25-Apr	27-Apr	11-May
2017	2/15/18	3/3/18	3/15/18	3/24/18	4/11/18	4/16/18	4/20/18	4/27/18	5/11/18
2016	11/23/16	3/28/17	4/1/17	4/5/17	4/12/17	5/1/17	5/5/17	5/7/17	6/21/17
2015	1/11/16	3/21/16	3/28/16	4/1/16	4/11/16	4/15/16	4/15/16	4/18/16	5/6/16
2014	12/5/14	12/8/14	12/15/14	12/24/14	4/10/15	4/17/15	4/27/15	4/29/15	4/29/15
2013	2/11/14	2/15/14	2/22/14	3/7/14	4/7/14	4/11/14	4/14/14	4/18/14	5/13/14
2012	12/3/12	4/1/13	4/1/13	4/10/13	4/17/13	4/19/13	4/19/13	4/22/13	5/7/13
2011	1/25/12	3/16/12	3/19/12	3/30/12	3/30/12	4/18/12	4/25/12	4/25/12	5/3/12
2010	12/8/10	12/20/10	1/3/11	4/13/11	4/20/11	4/22/11	4/27/11	4/27/11	5/10/11
2009	2/3/10	3/1/10	4/9/10	4/16/10	4/16/10	4/23/10	4/30/10	4/30/10	5/11/10
2008	2/23/09	4/2/09	4/10/09	4/15/09	4/16/09	4/24/09	5/2/09	5/7/09	5/7/09
2007	1/7/08	1/7/08	1/11/08	2/27/08	4/14/08	4/25/08	5/2/08	5/2/08	5/2/08
2006	2/7/07	2/14/07	2/14/07	4/9/07	4/17/07	4/17/07	4/30/07	5/1/07	5/14/07
2005	12/5/05	1/6/06	1/20/06	2/8/06	4/7/06	4/28/06	5/1/06	5/3/06	5/12/06
2004	12/10/04	2/22/05	3/4/05	4/1/05	4/20/05	4/22/05	4/22/05	4/27/05	5/19/05
2003	12/10/03	12/17/03	12/26/03	2/17/04	4/21/04	4/23/04	4/23/04	4/28/04	5/13/04
2002	12/16/02	1/6/03	2/19/03	3/19/03	4/11/03	4/23/03	4/25/03	4/25/03	5/15/03
2001	11/26/01	12/17/01	1/10/02	3/7/02	4/5/02	4/22/02	4/26/02	4/26/02	5/2/02
2000	2/16/01	2/16/01	2/16/01	2/16/01	4/9/01	4/18/01	4/23/01	4/25/01	5/4/01
1999	1/18/00	2/11/00	3/13/00	3/27/00	4/3/00	4/14/00	4/19/00	4/19/00	5/31/00

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
1998	11/30/1998	1/22/1999	3/23/1999	4/3/1999	4/10/1999	4/20/99	4/24/99	4/27/99	5/5/99
1997	11/25/97	3/9/98	3/18/98	3/25/98	4/3/98	4/15/98	4/22/98	4/27/98	6/5/98
1996	11/27/96	2/21/97	3/20/97	4/8/97	4/17/97	4/22/97	4/24/97	4/25/97	6/9/97
1995	12/15/95	3/5/96	3/22/96	3/27/96	4/2/96	4/7/96	4/26/96	4/29/96	6/1/96
1994	12/5/94	2/24/95	2/28/95	3/16/95	4/10/95	4/18/95	4/27/95	4/29/95	5/19/95

Table 2.5.5-13. Timing of juvenile CCV steelhead passage past Sherwood Harbor (Sacramento Trawl) for Brood Years 1998 – 2017 (Source: SacPas. Available at: http://www.cbr.washington.edu/sacramento/tmp/hrt_1552496507_849.html

Brood Year	First Passage Date	5% Passage Date	10% Passage Date	25% Passage Date	50% Passage Date	75% Passage Date	90% Passage Date	95% Passage Date	Last Passage Date
Average (1998 - 2017)	16-Jan	24-Jan	28-Jan	7-Feb	18-Feb	3-Mar	31-Mar	18-Apr	1-Jul
Median (1998 - 2017)	15-Jan	22-Jan	28-Jan	5-Feb	16-Feb	2-Mar	20-Mar	3-Apr	2-Jun
2017	1/12/18	1/16/18	1/22/18	1/26/18	2/24/18	3/3/18	3/17/18	3/21/18	5/14/18
2016	1/30/17	2/2/17	2/4/17	2/24/17	3/4/17	3/14/17	4/2/17	5/25/17	6/2/17
2015	1/11/16	1/11/16	1/29/16	2/5/16	2/8/16	2/8/16	2/18/16	3/18/16	4/4/16
2014	1/23/15	1/23/15	2/9/15	2/9/15	2/11/15	2/18/15	4/1/15	4/20/15	4/20/15
2013	1/31/14	2/7/14	2/8/14	2/11/14	2/12/14	2/15/14	2/16/14	3/5/14	4/18/14
2012	1/18/13	1/18/13	1/30/13	1/30/13	2/8/13	4/12/13	4/30/13	5/31/13	5/31/13
2011	1/17/12	1/23/12	1/23/12	1/30/12	2/13/12	2/24/12	3/9/12	3/30/12	5/1/12
2010	1/12/11	1/19/11	2/4/11	2/16/11	2/18/11	3/2/11	3/7/11	4/25/11	6/21/11
2009	1/27/10	2/1/10	2/3/10	2/10/10	2/17/10	2/24/10	4/16/10	4/19/10	6/10/10
2008	1/28/09	1/28/09	1/28/09	2/6/09	2/17/09	2/17/09	2/23/09	3/30/09	5/7/09
2007	1/11/08	1/16/08	1/18/08	2/8/08	2/11/08	2/15/08	2/15/08	2/19/08	3/3/08
2006	1/17/07	2/5/07	2/9/07	2/12/07	2/16/07	2/28/07	4/17/07	5/15/07	6/12/07
2005	1/20/06	1/27/06	2/1/06	2/13/06	2/17/06	3/3/06	3/13/06	3/27/06	6/14/06
2004	1/12/05	1/19/05	1/19/05	2/2/05	2/22/05	3/2/05	4/15/05	5/10/05	5/24/05
2003	1/2/04	1/2/04	1/16/04	1/30/04	2/4/04	2/20/04	3/8/04	3/15/04	12/6/04
2002	1/15/03	1/22/03	1/22/03	1/24/03	2/5/03	2/19/03	4/14/03	4/28/03	4/28/03
2001	1/15/02	1/22/02	1/24/02	1/26/02	2/23/02	3/9/02	12/16/02	12/16/02	12/16/02
2000	1/13/01	1/15/01	1/15/01	1/31/01	2/2/01	2/12/01	2/16/01	3/14/01	9/19/01
1999	1/3/00	1/17/00	1/17/00	1/20/00	1/27/00	2/11/00	3/13/00	3/22/00	4/21/00
1998	1/12/99	1/21/99	1/21/99	1/25/99	2/11/99	3/5/99	3/23/99	4/23/99	12/13/99

Table 2.5.5-14. Monthly diverted volumes in acre feet (af) from the Barker Slough Pumping Plant for the water years 2008-2018.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	2491	1395	937	4142	5739	7023	7068	7039	6355	5776	4797	2915
2009	3235	1909	95	1390	5504	5560	5264	5140	4368	3914	4305	1611
2010	921	1172	539	1467	4369	5856	6555	6434	6104	5131	4204	1382
2011	323	742	239	580	3426	4674	6151	6029	6255	4532	4315	3064
2012	2430	306	332	412	2033	5311	5792	5592	6490	5225	4607	1501
2013	952	1137	659	2314	6275	6573	6322	6452	5588	5932	3871	3468
2014	3728	1165	1133	3579	6615	4789	3928	4095	2568	3006	1218	833
2015	1121	1544	1629	3358	3561	3377	3313	4447	4186	4196	3285	1167
2016	977	948	19	519	3083	4735	5385	4753	4180	3670	2847	2050
2017	1014	944	222	411	2944	3265	3357	5895	5789	5513	4695	4182
2018	2735	3502	1562	325	4665	6013	5971	5975	5589	5011	5312	3431

Table 2.5.5-15. Average monthly diverted flows in cubic feet per second (cfs) from the Barker Slough Pumping Plant for the water years 2008-2018.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	40.5	25.1	15.2	69.6	93.3	118.0	114.9	114.5	106.8	93.9	80.6	47.4
2009	52.6	34.4	1.5	23.4	89.5	93.4	85.6	83.6	73.4	63.7	72.3	26.2
2010	15.0	21.1	8.8	24.7	71.1	98.4	106.6	104.6	102.6	83.4	70.7	22.5
2011	5.3	13.4	3.9	9.8	55.7	78.5	100.0	98.1	105.1	73.7	72.5	49.8
2012	39.5	5.5	5.4	6.9	33.1	89.3	94.2	90.9	109.1	85.0	77.4	24.4
2013	15.5	20.5	10.7	38.9	102.1	110.5	102.8	104.9	93.9	96.5	65.1	56.4
2014	60.6	21.0	18.4	60.1	107.6	80.5	63.9	66.6	43.2	48.9	20.5	13.6
2015	18.2	27.8	26.5	56.4	57.9	56.8	53.9	72.3	70.3	68.2	55.2	19.0
2016	15.9	17.1	0.3	8.7	50.1	79.6	87.6	77.3	70.2	59.7	47.8	33.3
2017	16.5	17.0	3.6	6.9	47.9	54.9	54.6	95.9	97.3	89.7	78.9	68.0
2018	44.5	63.1	25.4	5.5	75.9	101.1	97.1	97.2	93.9	81.5	89.3	55.8
Mean	29.5	24.2	10.9	28.3	71.3	87.4	87.4	91.4	87.8	76.7	66.4	37.9
Median	18.2	21.0	8.8	23.4	71.1	89.3	94.2	95.9	93.9	81.5	72.3	33.3
Minimum	5.3	5.5	0.3	5.5	33.1	54.9	53.9	66.6	43.2	48.9	20.5	13.6
Maximum	60.6	63.1	26.5	69.6	107.6	118.0	114.9	114.5	109.1	96.5	89.3	68.0

Table 2.5.5-16. Catches of Chinook salmon in the North Bay Aqueduct Larval Fish Survey (1994-2004)

Date	Species	Number Caught	Site Location
2/27/2004	Chinook salmon	1	724
2/28/2001	Chinook salmon	2	724, 726
3/8/2001	Chinook salmon	1	724
2/15/2000	Chinook salmon	5	723(1), 724 (3), 726 (1)
3/18/1999	Chinook salmon	1	718
3/7/1998	Chinook salmon	1	721
2/23/1997	Chinook salmon	1	726

Table 2.5.5-17. Timing of unclipped juvenile winter-run Chinook salmon salvage (length at date) at the CVP and SWP fish salvage facilities for Brood Years 1994 – 2017.

Start Year	First Salvage Date	5% Salvage Date	10% Salvage Date	25% Salvage Date	50% Salvage Date	75% Salvage Date	90% Salvage Date	95% Salvage Date	Last Salvage Date	Number Salvaged
Avera ge (1994- 2017)	26-Dec	9-Jan	22-Jan	4-Feb	24-Feb	11-Mar	24-Mar	29-Mar	22-Apr	1210
Median (1994 - 2017)	18-Dec	4-Jan	25-Jan	14-Feb	2-Mar	14-Mar	24-Mar	31-Mar	21-Apr	811
2017	2/5/18	3/1/18	3/6/18	3/22/18	3/25/18	3/29/18	4/3/18	4/5/18	5/15/18	237
2016	12/20/16	12/20/16	12/20/16	12/27/16	2/14/17	3/29/17	4/5/17	4/24/17	4/24/17	40
2015	12/28/15	12/28/15	1/5/16	1/14/16	1/28/16	2/22/16	3/22/16	3/22/16	3/22/16	36
2014	12/24/14	12/24/14	12/24/14	12/26/14	1/4/15	1/21/15	1/21/15	2/3/15	3/31/15	53
2013	3/3/14	3/5/14	3/6/14	3/9/14	3/15/14	3/20/14	4/4/14	4/10/14	4/14/14	192
2012	12/4/12	12/15/12	12/16/12	12/19/12	3/9/13	3/21/13	3/25/13	3/28/13	4/6/13	271
2011	1/25/12	2/16/12	2/27/12	3/7/12	3/17/12	3/23/12	3/31/12	4/1/12	5/29/12	841
2010	12/3/10	12/7/10	12/29/10	1/29/11	3/1/11	3/14/11	3/20/11	3/23/11	4/13/11	1703
2009	12/8/09	1/30/10	2/6/10	2/24/10	3/5/10	3/18/10	3/22/10	3/26/10	4/20/10	1064
2008	12/30/08	1/9/09	2/26/09	3/3/09	3/8/09	3/13/09	3/16/09	3/18/09	4/17/09	582
2007	1/11/08	1/18/08	1/28/08	2/17/08	3/1/08	3/13/08	3/22/08	3/26/08	4/29/08	660
2006	12/18/06	1/22/07	2/8/07	2/25/07	3/2/07	3/9/07	3/24/07	4/3/07	4/22/07	2764
2005	12/12/05	12/23/05	1/24/06	2/21/06	3/1/06	3/14/06	3/26/06	4/1/06	5/3/06	1008
2004	1/2/05	1/6/05	1/11/05	2/5/05	3/1/05	3/16/05	3/26/05	4/4/05	4/20/05	469
2003	12/15/03	1/6/04	1/27/04	2/24/04	3/1/04	3/10/04	3/16/04	3/19/04	5/19/04	2728
2002	12/18/02	12/24/02	12/26/02	1/7/03	2/24/03	3/5/03	3/19/03	3/26/03	5/7/03	2265
2001	12/5/01	12/13/01	12/18/01	12/31/01	3/5/02	3/25/02	3/31/02	4/6/02	4/27/02	1442
2000	12/12/00	2/2/01	2/14/01	2/23/01	3/6/01	3/13/01	3/19/01	3/23/01	4/23/01	5932
1999	1/2/00	1/26/00	1/28/00	2/12/00	2/19/00	3/17/00	3/30/00	4/3/00	4/14/00	1924
1998	1/24/99	2/23/99	3/5/99	3/13/99	3/21/99	4/1/99	4/8/99	4/11/99	4/26/99	1510
1997	12/4/97	12/6/97	12/8/97	12/11/97	1/4/98	3/9/98	3/21/98	3/23/98	3/27/98	726
1996	12/10/96	12/12/96	3/8/97	3/20/97	3/26/97	3/27/97	3/30/97	3/31/97	4/6/97	388
1995	12/18/95	1/2/96	1/7/96	1/16/96	1/25/96	2/7/96	3/16/96	4/2/96	4/18/96	781
1994	12/16/94	12/24/94	12/28/94	1/13/95	1/20/95	1/29/95	4/21/95	4/26/95	5/6/95	1416

 $Table \ 2.5.5-18. \ Timing \ of unclipped juvenile \ CV \ spring-run \ sized \ Chinook \ salmon \ salvage \ (length \ at \ date) \ at \ the \ CVP \ and \ SWP \ fish \ salvage \ facilities \ for \ Brood \ Years \ 1994-2017.$

Start Year	First Salvage Date	5% Salvage Date	10% Salvage Date	25% Salvage Date	50% Salvage Date	75% Salvage Date	90% Salvage Date	95% Salvage Date	Last Salvage Date	Start Year
Average (1994-2017)	12-Feb	26-Mar	31-Mar	7-Apr	19-Apr	28-Apr	8-May	14-May	4-Jun	14762
Median (1994 - 2017)	19-Feb	27-Mar	30-Mar	6-Apr	18-Apr	27-Apr	7-May	13-May	4-Jun	8832
2017	3/14/18	3/27/18	3/28/18	3/30/18	4/7/18	4/16/18	5/2/18	5/9/18	5/23/18	9487
2016	2/16/17	4/10/17	4/18/17	4/27/17	5/7/17	5/14/17	5/22/17	6/1/17	6/29/17	26713
2015	2/11/16	2/12/16	2/28/16	3/18/16	4/17/16	5/2/16	5/13/16	5/14/16	5/19/16	158
2014	3/30/15	3/30/15	3/30/15	4/5/15	4/22/15	4/24/15	5/4/15	5/18/15	5/18/15	50
2013	3/13/14	3/19/14	3/21/14	4/5/14	4/9/14	4/19/14	4/23/14	4/29/14	5/10/14	484
2012	3/17/13	3/24/13	3/27/13	4/8/13	4/24/13	5/2/13	5/8/13	5/13/13	5/25/13	909
2011	3/10/12	3/25/12	3/28/12	4/2/12	4/15/12	4/21/12	5/2/12	5/7/12	6/8/12	1063
2010	1/3/11	4/13/11	4/22/11	4/30/11	5/7/11	5/16/11	5/29/11	6/3/11	6/24/11	17654
2009	3/9/10	3/31/10	4/6/10	4/16/10	5/2/10	5/16/10	5/26/10	5/29/10	6/5/10	4068
2008	3/15/09	3/30/09	4/2/09	4/11/09	4/23/09	5/1/09	5/10/09	5/13/09	6/15/09	4730
2007	3/11/08	4/3/08	4/7/08	4/18/08	4/27/08	5/4/08	5/10/08	5/14/08	6/5/08	5100
2006	3/2/07	4/1/07	4/4/07	4/10/07	4/15/07	4/18/07	4/21/07	4/24/07	5/30/07	3378
2005	2/9/06	3/23/06	4/4/06	4/12/06	5/2/06	5/25/06	5/29/06	6/5/06	6/19/06	5822
2004	2/25/05	3/25/05	3/27/05	4/4/05	4/21/05	4/29/05	5/12/05	5/22/05	6/11/05	14694
2003	1/18/04	3/9/04	3/14/04	3/21/04	4/4/04	4/13/04	4/27/04	5/4/04	5/26/04	4534
2002	1/7/03	3/21/03	3/25/03	3/29/03	4/6/03	4/14/03	4/26/03	4/30/03	5/29/03	15706
2001	1/1/02	3/28/02	3/30/02	4/3/02	4/8/02	4/14/02	4/21/02	4/30/02	6/3/02	8177
2000	9/26/00	3/25/01	3/30/01	4/3/01	4/12/01	4/18/01	4/28/01	5/2/01	5/14/01	17940
1999	2/13/00	3/29/00	4/2/00	4/6/00	4/10/00	4/14/00	4/24/00	4/28/00	6/1/00	42468
1998	2/2/99	3/28/99	4/4/99	4/10/99	4/18/99	4/26/99	5/7/99	5/13/99	6/4/99	46655
1997	2/22/98	3/25/98	3/26/98	4/1/98	4/29/98	5/9/98	5/18/98	5/22/98	6/25/98	30589
1996	2/8/97	3/24/97	3/25/97	3/28/97	4/3/97	4/9/97	4/17/97	4/24/97	6/5/97	42906
1995	2/7/96	4/5/96	4/7/96	4/10/96	4/13/96	5/2/96	5/23/96	5/27/96	6/12/96	26785
1994	2/22/95	4/13/95	4/19/95	4/29/95	5/11/95	5/26/95	6/8/95	6/11/95	6/30/95	24224

Table 2.5.5-19. Timing of juvenile unclipped CCV steelhead salvage at the CVP and SWP fish salvage facilities for Brood Years 1998 - 2017.

Start Year	First Salvage Date	5% Salvage Date	10% Salvage Date	25% Salvage Date	50% Salvage Date	75% Salvage Date	90% Salvage Date	95% Salvage Date	Last Salvage Date	Number Salvaged
Average (1998-2017)	4-Dec	23-Jan	8-Feb	24-Feb	19-Mar	10-Apr	1-May	13-May	17-Jun	1395
Median (1998 - 2017)	19-Dec	26-Jan	10-Feb	24-Feb	20-Mar	6-Apr	25-Apr	9-May	22-Jun	1074
2017	2/1/18	3/14/18	3/17/18	3/24/18	4/3/18	4/15/18	5/15/18	5/23/18	6/11/18	1119
2016	11/27/16	11/27/16	12/31/16	1/25/17	5/8/17	5/24/17	6/6/17	6/16/17	6/16/17	65
2015	1/20/16	2/1/16	2/2/16	2/16/16	3/15/16	3/25/16	4/3/16	5/2/16	5/23/16	119
2014	11/16/14	11/16/14	2/16/15	2/17/15	2/27/15	4/17/15	4/28/15	5/8/15	5/8/15	43
2013	1/23/14	2/19/14	2/20/14	3/7/14	3/25/14	4/7/14	4/10/14	4/23/14	5/6/14	185
2012	11/23/12	1/22/13	2/12/13	3/22/13	3/31/13	4/26/13	5/13/13	5/27/13	7/2/13	797
2011	9/12/11	1/5/12	3/9/12	3/24/12	3/30/12	4/4/12	4/18/12	4/21/12	6/3/12	342
2010	10/28/10	2/12/11	2/17/11	3/2/11	4/13/11	5/28/11	6/12/11	6/20/11	6/27/11	738
2009	12/20/09	2/3/10	2/6/10	2/10/10	2/23/10	4/2/10	5/31/10	6/19/10	6/21/10	1030
2008	1/25/09	2/11/09	2/20/09	3/2/09	3/16/09	3/30/09	4/28/09	5/11/09	7/7/09	372
2007	1/18/08	1/30/08	2/2/08	2/12/08	2/23/08	3/14/08	4/22/08	5/4/08	7/6/08	984
2006	12/31/06	2/12/07	2/15/07	3/5/07	3/24/07	4/9/07	4/17/07	4/20/07	6/7/07	2774
2005	1/4/06	2/10/06	2/24/06	3/4/06	3/30/06	5/31/06	6/14/06	6/24/06	7/5/06	1601
2004	11/3/04	1/11/05	1/28/05	2/25/05	3/25/05	4/14/05	5/21/05	6/3/05	7/3/05	1351
2003	12/18/03	1/12/04	1/28/04	2/15/04	3/1/04	3/12/04	3/30/04	4/5/04	5/27/04	1785
2002	12/20/02	1/8/03	1/12/03	1/21/03	3/3/03	3/22/03	4/14/03	5/11/03	6/24/03	2189
2001	12/20/01	1/18/02	1/25/02	2/22/02	3/12/02	3/29/02	4/14/02	4/29/02	7/4/02	1632
2000	10/31/00	1/22/01	2/9/01	2/23/01	3/10/01	3/25/01	4/5/01	4/13/01	6/1/01	4610
1999	8/25/99	1/22/00	1/30/00	2/10/00	2/20/00	3/7/00	4/5/00	4/17/00	7/29/00	3866
1998	10/23/98	2/6/99	2/11/99	3/15/99	4/8/99	4/19/99	5/18/99	5/26/99	7/2/99	2292

Table 2.5.5-20. Total number of listed salmonids and sDPS green sturgeon collected at the Rock Slough Intake for years 1999-2011, prior to the operation of the Rock Slough Fish Screen.

Species	Total Number Collected 1999-2011	Number Collected	by Year
	122	Headworks 1999-2011	Pumping Plant #1 2004-2011
Winter-run Chinook salmon	0	All years - 0	All years - 0
Spring-run Chinook	15 juveniles	2004 - 3	2004 -3
salmon	5.0	2005 - 4	2006 - 1
		2006 - 3	Company of the
		2008 - 1	
Fall-run Chinook	23 juveniles	2000 - 3	2004 - 2
salmon	3 00	2004 - 5	
uit a statebook muu kala .		2005 - 10	
		2006 - 1	
		2008 - 2	
Central Valley	15 juveniles	2005 -4	All years - 0
steelhead	Tables de €reste du la ribellul parece entresa.	2006 - 2	20 - 20 - 20 - 20 - 20 - 20 - 20 - 20 -
		2007 - 1	
		2008 - 8	
Green sturgeon	0	All years - 0	All years - 0

Note: No monitoring was conducted at the Headworks in 2010 and 2011 due to the construction of the Rock Slough Fish Screen. Monitoring continued at Pumping Plant #1 until the Rock Slough Fish Screen became operational in October 2011.

Table 2.5.5-21. Proposed Action Component minus Current Operations Scenario for Old and Middle River (OMR) flows, monthly averages.

Proposed Action 011519 minus Current Operations 011319

	Monthly Flow (CFS)												
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Probability of Exceedance													
10%	723	727	-110	-125	-1,327	168	-3,943	4,197	-1,246	171	91	241	
20%	483	678	72	-1,694	-2,397	-1,813	-3,565	-3,001	-2,036	1,463	-148	466	
30%	564	815	244	-1,161	-1,696	-929	-3,338	-2,928	-1,000	713	-483	271	
40%	521	522	581	-168	-964	-1,016	-3,325	-3,063	-1,000	50	-117	-166	
50%	-198	-75	581	194	-319	-499	-2,808	-2,944	-1,000	236	-213	-445	
60%	-1,257	-520	581	-7	517	369	-2,236	-2,721	-183	62	-81	180	
70%	-2,012	-982	657	-226	108	76	-2,230	-2,492	0	-12	24	394	
80%	-2,067	-811	2,516	-226	-193	0	-2,110	-2,564	0	-182	35	383	
90%	-2,090	580	-63	-226	-250	0	-2,102	-2,605	0	68	-114	461	
Long Term Full Simulation Period ²	427	192	468	-348	-598	-359	-2,706	-2,767	-658	232	-150	215	
Water Year Types b,c													
Wet (32%)	-1,476	-1,096	314	-295	297	493	-4,053	-3,907	225	34	78	238	
Above Normal (16%)	-1,495	643	1,450	-729	-96	256	-3,865	-3,550	28	-463	56	387	
Below Normal (13%)	756	736	566	-652	-1,001	-555	-2,603	-2,802	-1,593	-226	-1,016	-71	
Dry (24%)	338	1,034	155	-139	-1,271	-1,124	-1,482	-1,963	-1,487	1,067	-270	244	
Critical (15%)	641	593	167	-120	-1,587	-1,412	-668	-755	-1,079	443	129	195	

a Based on the 82-year simulation period.

b As defined by the Sacremento Velley 40-30-30 Index Water Year Hydrologic Classification (SWRC8 D-1641, 1999).

c These results are displayed with calendar year-year type sorting.

d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

e These are dreft results meant for qualitative analysis and are subject to revision.

Table 2.5.5-22. Proposed Action Component minus Current Operations Scenario for total Delta Exports, monthly delivery.

Proposed Action 011519 minus Current Operations 011319

					M	onthly Deli	very (CFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	3,461	32	-35	-126	-140	-449	4,529	4,571	-521	11	0	0
20%	3,638	1,945	-758	46	-78	-565	4,815	4,974	-90	0	0	0
30%	3,215	2,081	-1,670	533	15	-359	4,497	4,235	-364	144	-20	0
40%	2,330	1,575	-773	312	213	53	4,438	4,086	-324	-93	0	130
50%	1,299	1,172	-700	398	402	211	3,838	3,693	747	-506	543	1,019
60%	361	491	-696	308	373	318	3,062	2,836	1,296	-415	926	747
70%	182	-170	-700	380	729	1,145	1,707	2,211	1,401	-783	120	-136
80%	27	-231	-47	680	1,703	1,225	1,304	1,734	2,304	-1,462	151	-173
90%	-174	-21	-118	1,381	2,951	2,198	954	877	1,441	-665	32	-105
Long Term Full Simulation Period ^a	1,397	726	-548	393	742	404	2,971	2,977	660	-272	149	215
Water Year Types b,c												
Wet (32%)	2,688	2,341	-474	312	-31	-502	4,476	4,244	-232	-24	-79	304
Above Normal (16%)	2,645	258	-1,579	899	149	-225	4,433	3,966	-152	400	-58	144
Below Normal (13%)	99	52	-615	737	1,071	548	2,737	2,865	1,656	226	1,099	518
Dry (24%)	445	-281	-157	148	1,371	1,234	1,549	2,069	1,544	-1,161	252	69
Critical (15%)	24	34	-183	110	1,709	1,535	713	781	1,089	-512	-178	64

a Based on the 82-year simulation period.

Table 2.5.5-23. Intervals of wild CCV steelhead loss density values for water years 2010 – 2018; (fish loss/thousand acre feet [TAF]).

Fish Loss/ TAF	Water Year								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
0 to <2	67	61	19	32	23	5	20	14	30
2 to <4	17	21	11	16	2	3	6	1	22
4 to <6	10	6	7	13	2	3	0	0	10
6 to <8	1	2	3	7	1	0	1	0	10
8 to <10	1	3	2	5	0	0	0	0	5
10 to <12	2	2	0	8	0	0	0	0	1
12 to <14	0	0	2	0	0	0	0	0	1
14 to <16	1	0	0	0	0	0	0	0	1
16 to <18	0	0	1	1	0	0	0	0	0
18 to <20	0	0	0	2	0	0	0	0	0
20 to <22				0					
22 to <24				0					
24 to <26				1		6			
26 to <28				0					

le As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).

c These results are displayed with calendar year - year type sorting.

d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

e These are draft results meant for qualitative analysis and are subject to revision.

Fish Loss/ TAF	Water Year								
28 to <30				0					Ì
30 to <32				1					
-	5 	. 	17.	(-)		1 .0 0	: :	-	-
# > 8 fish/TAF	5	5	5	18	0	0	0	0	8
# > 10 fish/TAF	3	2	3	13	0	0	0	0	3
Difference	2	3	2	5	0	0	0	0	5
% change	40%	60%	40%	28%	0%	0%	0%	0%	63%
-	-			-	-:	-	:	-	-

Table 2.5.5-24. Average annual adipose fin-clipped winter-run-sized Chinook salmon juvenile salvage and loss from brood year 1999-2017. Because the number of juveniles released are known genetic winter-run Chinook salmon, but some winter-run-sized fin-clipped Chinook salmon are not genetic winter-run, this table overestimates the loss as a percent of release.

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release	
1999	987	2,482	153,908	1.61%	
2000	965	3,295	30,840	10.68%	
2001	2,259	6,734	166,206	4.05%	
2002	7,751	22,748	252,684	9.00%	
2003	6,094	19,319	233,613	8.27%	
2004	1,103	3,964	218,617	1.81%	
2005	477	1,251	168,261	0.74%	
2006	1,353	2,034	173,344	1.17%	
2007	2,919	5,618	196,288	2.86%	
2008	179	435	71,883	0.61%	
2009	1,230	2,356	146,211	1.61%	
2010	463	1,449	198,582	0.73%	
2011	460	1,210	123,859	0.98%	
2012	187	595	194264	0.31%	
2013	6	12	181857	0.01%	
2014	62	214	193155	0.11%	
2015	213	628	420006	0.15%	
2016	368	1,010	141388	0.71%	
2017	48	183	431,793	0.04%	
Mean	1,428	3,976	194,566	2.39%	
Median	477	1,449	181,857	0.98%	
SD	2,101	6,311	96,720	3.27%	
95% CI	1,013	3,042	46,618	1.58%	

Table 2.5.5-25. Unclipped (wild) annual winter-run Chinook salmon juvenile salvage and loss from brood year 1999-2017.

Brood Year	Total Fish Salvage	Total Fish Loss	JPE	Loss/JPE
1992	1,053	4,003	246,157	1.6%
1993	1,337	2,769	90,546	3.06%
1994	1,416	4,582	74,491	6.15%
1995	781	2,376	338,107	0.70%
1996	397	630	165,069	0.38%
1997	726	1,525	138,316	1.10%
1998	1,514	3,715	454,792	0.82%
1999	1,936	5,828	289,724	2.01%
2000	5,932	20,062	370,221	5.42%
2001	1,442	3,331	1,864,802	0.18%
2002	2,277	6,816	2,136,747	0.32%
2003	2,728	7,779	1,896,649	0.41%
2004	469	1,373	881,719	0.16%
2005	1,008	2,601	3,831,286	0.07%
2006	2,764	3,297	3,739,069	0.09%
2007	660	1,292	589,911	0.22%
2008	582	1,515	617,783	0.25%
2009	1,064	1,656	1,179,633	0.14%
2010	1,703	4,360	332,012	1.31%
2011	841	2,079	162,051	1.28%
2012	271	732	532,809	0.14%
2013	192	322	1,196,387	0.03%
2014	53	106	124,521	0.09%
2015	36	56	101,716	0.06%
2016	46	111	166,189	0.07%
2017	114	301	201,409	0.15%
Mean	1,205	3,201	835,466	1.01%
Median	925	2,228	354,164	0.28%
SD	1,247	4,027	1,051,836	1.59%
95% CI	504	1,626	424,846	0.64%

Table 2.5.5-26. Estimated annual loss of winter-run Chinook salmon (based on the salvage-density method) for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario. There is a specific loss threshold for winter-run Chinook salmon from December through March.

Water Yeartype	Predicted loss under COS	Predicted loss under PA	PA-COS	% change
Wet	12,417	13,788	1,371	11
Above Normal	6,369	6,805	437	7
Below Normal	5,830	6,812	982	17
Dry	4,106	5,070	965	23
Critical	1,230	1,702	472	38

Table 2.5.5-27. Estimated monthly loss of winter-run Chinook salmon (based on the salvage-density method) for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities, all water year types combined. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Winter-run Chinook salmon									
Month	Predicted loss under COS	Predicted loss under PA	PA-COS	% change					
October	0	0	0						
November	0	0	0						
December	518	459	-59	-11					
January	2,807	2,987	180	6					
February	903	922	19	2					
March	7,141	6,703	-438	-6					
April	1,046	2,713	1,667	159					
May	2	4	2	135					
June	0	0	0						
July	0	0	0						
August	0	0	0						
September	0	0	0						

Table 2.5.5-28. Estimated entrainment index (number of fish lost, based on normalized historical loss data and the salvage-density method) of juvenile winter-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Water Year Type	-	: -	State Water Project	(4)	-	Central Valley Project
-	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
Wet	10,961	12,235	1,275 (11.6%)	1,456	1,553	97 (6.7%)
Above Normal	5,613	5,911	298 (5.3%)	756	895	139 (18.4%)
Below Normal	4,807	5,717	910 (18.9%)	1,024	1,095	71 (7.0%)
Dry	3,146	3,938	791 (25.1%)	959	1,133	173 (18.1%)
Critical	837	1,130	294 (35.1%)	394	572	178 (45.3%)

Table 2.5.5-29. Estimated entrainment index (number of fish lost, based on normalized historical loss data and the salvage-density method) of juvenile winter-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Wet water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	(#)	State Water Project	-	2 8 3	Central Valley Project
N ele t	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	412	361	-51 (-12.4%)	106	98	-7 (-7.0%)
January	2,641	2,821	180 (6.8%)	166	166	0 (0.1%)
February	701	734	33 (4.7%)	202	188	-14 (-7.1%)
March	6,295	5,877	-418 (-6.6%)	846	826	-20 (-2.4%
April	910	2,439	1,529 (168 %)	136	274	139 (102.3%)
May	2	4	2 (135%)	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	10,961	12,235	1,275 (11.6%)	1,456	1,553	97 (6.7%)

Table 2.5.5-30. Estimated entrainment index (number of fish lost, based on normalized historical loss data and the salvage-density method) of juvenile winter-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Above Normal water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	2	State Water Project	-	-	Central Valley Project
-	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	359	359	0 (0.1%)	20	20	0
January	682	816	134 (19.7%)	66	71	6 (8.5%)

Month	2.	120	State Water Project	(2)	14	Central Valley Project
February	2,558	2,633	76 (3.0%)	239	241	2 (0.9%)
March	1,940	1,850	-91 (-4.7%)	355	352	-3 (-0.8%)
April	75	253	178 (238.2%)	70	196	125 (178.1%)
May	0	0	0	4	13	9 (228.7%)
June	0	0	0	1	1	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	5,613	5,911	298 (5.3%)	756	895	139 (18.4%)

Table 2.5.5-31. Estimated entrainment index (number of fish lost, based on normalized historical loss data and the salvage-density method) of juvenile winter-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Below Normal water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	-	-	Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	110	100	-10 (-9.0%)	46	42	-4 (-7.8%)
January	328	383	55 (16.7%)	101	109	8 (8.3%)
February	1,677	2,020	343 (20.5%)	410	466	55 (13.5%)
March	2,630	3,042	412 (15.7%)	467	478	11 (2.4%)
April	21	54	33 (155.8%)	0	0	0
May	41	118	77 (188.7%)	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	4,807	5,717	910 (18.9%)	1,024	1,095	71 (7.0%)

Table 2.5.5-32. Estimated entrainment index (number of fish lost, based on normalized historical loss data and the salvage-density method) of juvenile winter-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities –Dry water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-		State Water Project	-		Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	227	228	1 (0.5%)	37	34	-3 (-9.0%)
January	125	130	5 (4.1%)	78	79	1 (1.0%)
February	726	867	141 (19.4%)	286	364	78 (27.4%)
March	1,974	2,539	565 (28.6%)	514	595	80 (15.6%)
April	95	174	79 (83.2%)	44	61	17 (39.8%)

Month	4	- 4	State Water Project	- 1	944	Central Valley Project
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	3,146	3,938	791 (25.1%)	959	1,133	173 (18.1%)

Table 2.5.5-33. Estimated entrainment index (number of fish lost, based on normalized historical loss data and the salvage-density method) of juvenile winter-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities –Critical water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	· ·	-	State Water Project	-	-	Central Valley Project
22	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	145	147	2 (1.6%)	45	46	1 (2.0%)
February	222	300	78 (35.0%)	115	164	48 (41.8%)
March	447	641	194 (43.4%)	229	357	128 (56.1%)
April	22	42	19 (86.1%)	4	5	1 (17.2%)
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	837	1,130	294 (35.1%)	394	572	178 (45.3%)

Table 2.5.5-34. Average annual adipose fin-clipped CV spring-run Chinook salmon juvenile salvage and loss from brood year 1999-2017.

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release
1999	2,226.00	8,657.00	171,340.00	5.0525%
2000	270.00	726.00	No Data	No Data
2001	2,754.00	4,373.00	254,591.00	1.7177%
2002	864.00	2,520.00	128,200.00	1.9657%
2003	205.00	586.00	No Data	No Data
2004	2,488.00	3,633.00	561,920.00	0.6465%
2005	601.00	632.00	No Data	No Data
2006	31.00	44.00	5,219,080.00	0.0008%
2007	107.00	251.00	214,159.00	0.1172%
2008	15.00	11.00	108,085.00	0.0102%
2009	42.00	73.00	51,762.00	0.1410%
2010	276.00	793.00	3,258,949.00	0.0243%
2011	142.00	289.00	2,314,266.00	0.0125%

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release	
2012	7.00	15.00	92,396.00	0.0162%	
2013	12.00	8.00	2,997,011.00	0.0003%	
2014	8.00	7.00	2,090,391.00	0.0003%	
2015	650.00	560.00	2,127,482.00	0.0263%	
2016	962.70	1,787.00	1,788,310.00	0.0999%	
2017	1,010.00	1,745.27	663,434.00	0.2631%	
Mean	667	1,406	1,377,586	0.6309%	
Median	270	586	612,677	0.0631%	
SD	881	2,169	1,524,528	1.3293%	
95% CI	425	1,045	734,799	0.6407%	

Table 2.5.5-35. Unclipped (wild) annual CV spring-run Chinook salmon juvenile salvage and loss from brood year 1999-2017.

Brood Year	Total Fish Salvage	Total Fish Loss
1992	7,721	13,265
1993	3,555	3,785
1994	24,200	29,905
1995	26,785	36,851
1996	42,908	54,855
1997	30,597	24,943
1998	46,655	105,615
1999	42,513	90,118
2000	17,940	40,696
2001	8,177	10,206
2002	15,706	40,383
2003	4,534	10,985
2004	14,694	27,319
2005	5,822	13,002
2006	3,378	5,213
2007	5,100	11,771
2008	4,730	8,840
2009	4,068	6,082
2010	17,654	52,505
2011	1,063	2,394
2012	909	2,496
2013	484	349
2014	50	70
2015	158	298
2016	26,713	72,013
2017	9,487	18,314
Mean	14,062	26,241
Median	7,949	13,134
SD	14,276	28,597

Brood Year	Total Fish Salvage	Total Fish Loss
95% CI	5,766	11,550

Table 2.5.5-36. Estimated annual adjusted loss of CV spring-run Chinook salmon (based on the salvage-density method) for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario, though there is not a specific loss threshold for spring-run Chinook salmon.

Water Yeartype	Predicted loss under COS	Predicted loss under PA	PA-COS	% change
Wet	851	1,732	881	104
Above Normal	461	1,193	732	159
Below Normal	116	234	117	101
Dry	278	482	205	74
Critical	153	249	97	64

Table 2.5.5-37. Estimated monthly adjusted loss of CV spring-run Chinook salmon (based on the salvage-density method) for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities, all water year types combined. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario, though there is not a specific loss threshold for spring-run Chinook salmon.

CV spr	ing-run Chin	ook salmon	(adjusted	loss)	
Month	Predicted loss under COS	Predicted loss under PA	PA-COS	% change	
October	0	0	0	48	
November	0	0	0		
December	0	0	0	OHE.	
January	0	0	0	744	
February	5	5	0	3	
March	191	181	-9	-5	
April	437	1,062	625	143	
May	207	473	266	128	
June	11	10	0	-2	
July	0	0	0		
August	0	0	0		
September	0	0	0	122	

Table 2.5.5-38. Table showing estimation procedure for estimate juvenile production estimate (JPE) for CV spring-run Chinook salmon. Winter-run and spring-run Chinook salmon escapement from May 9, 2019 GrandTab. Winter-run JPE from NMFS JPE letters.

Water Year	Brood Year	WR escapement	WR JPE	JPE multiplier (WR JPE/WR escapement)	SR Tributary escapement	Estimated SR JPE (SR Tributary escapement x JPE multiplier)
2010	2009	4,537	1,179,633	260	3,457	898,830
2011	2010	1,596	332,012	208	2,962	616,178
2012	2011	827	162,051	196	5,805	1,137,492
2013	2012	2,671	532,809	199	18,688	3,727,868
2014	2013	6,084	1,196,387	197	19,516	3,837,720
2015	2014	3,015	124,521	41	7,125	294,266
2016	2015	3,440	101,716	30	1,195	35,334
2017	2016	1,547	166,189	107	6,453	693,224
2018	2017	977	201,409	206	1,059	218,313

Table 2.5.5-39. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CV spring-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Water Year Type	-	:	State Water Project	-	-	Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
Wet	26,589	58,046	31,457 (118%)	15,943	28,560	12,617 (79.1%)
Above Normal	16,286	43,560	27,273 (167.5%)	6,770	16,100	9,329 (137.8%)
Below Normal	4,632	9,819	5,187 (112.0%)	1,183	1,860	677 (57.3%)
Dry	10,659	19,692	9,034 (84.8%)	3,226	4,426	1,200 (37.2%)
Critical	5,131	9,272	4,141 (80.7%)	2,497	3,201	705 (28.2%)

Table 2.5.5-40. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CV spring-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Wet water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	:-	-	Central Valley Project
<u> </u>	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)

Month	-	-	State Water Project	-	-	Central Valley Project
October	7	10	3 (48.5%)	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	198	208	9 (4.7%)	29	27	-2 (-7.1%)
March	5,761	5,378	-382 (-6.6%)	3,766	3,676	-90 (-2.4%)
April	13,515	36,218	22,703 (168.0%)	8,353	16,897	8,544 (102.3%)
May	6,755	15,874	9,120 (135.0%)	3,620	7,797	4,177 (115.4%)
June	354	357	4 (1.0%)	175	163	-12 (-6.7%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	26,589	58,046	31,457 (118.3%)	15,943	28,560	12,617 (79.1%)

Table 2.5.5-41. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CV spring-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Above Normal water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	(#/	-	Central Valley Project
##(cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	4	5	1 (19.7%)	6	7	1 (8.5%)
February	56	57	2 (3.0%)	18	18	0 (0.9%)
March	4,610	4,395	-215 (-4.7%)	1,663	1,649	-14 (-0.8%)
April	9,774	33,057	23,283 (238.2%)	4,442	12,353	7,911 (178.1%)
May	1,778	5,974	4,196 (236.0%)	627	2,061	1,434 (228.7%)
June	55	62	7 (13.0%)	14	13	-2 (-10.8%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	9	9	0	0	0	0
Annual Average	16,286	43,560	27,273 (167.5%)	6,770	16,100	9,329 (137.8%)

Table 2.5.5-42. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CV spring-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Below Normal water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	=	-	State Water Project	-		Central Valley Project
200	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	9	11	2 (16.7%)	0	0	0
February	22	27	5 (20.5%)	0	0	0
March	1,561	1,806	245 (15.7%)	577	591	14 (2.4%)
April	2,431	6,219	3,788 (155.8%)	480	933	453 (94.4%)
May	608	1,756	1,148 (188.7%)	126	336	210 (167.0%)
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	4,632	9,819	5,187 (112.0%)	1,183	1,860	677 (57.3%)

Table 2.5.5-43. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CV spring-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities –Dry water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	12	-	Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	6	6	0
February	0	0	0	2	3	1 (27.4%)
March	1,084	1,394	310 (28.6%)	591	683	92 (15.6%)
April	6,600	12,089	5,489 (83.2%)	2,510	3,509	999 (39.8%)
May	2,975	6,210	3,235 (108.7%)	112	218	106 (94.5%)
June	0	0	0	4	6	2 (39.8%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	10,659	19,692	9.034 (84.8%)	3,226	4,426	1,200 (37.2%)

Table 2.5.5-44. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CV spring-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities—Critical water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	-		Central Valley Project
: 	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	138	198	60 (43.4%)	95	148	53 (56.1%)
April	2,736	5,092	2,356 (86.1%)	1,345	1,577	232 (17.2%)
May	2,240	3,909	1,669 (74.5%)	1,054	1,471	418 (39.6%)
June	17	73	56 (319.6%)	3	6	2 (67.8%)
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	5,131	9,272	4,141 (80.7%)	2,497	3,201	705 (28.2%)

Table 2.5.5-45. Annual clipped juvenile CCV steelhead salvage and loss from Brood Years 1999 to 2017.

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release
1999	181	367	1476342	0.02%
2000	5432	7950	1398412	0.57%
2001	8191	15723	1633825	0.96%
2002	1885	3345	1496220	0.22%
2003	10388	28222	1523646	1.85%
2004	7976	20917	1434217	1.46%
2005	2046	4148	1963911	0.21%
2006	2169	8110	1644777	0.49%
2007	2853	10052	1915192	0.52%
2008	2836	7548	2085566	0.36%
2009	994	2489	1391770	0.18%
2010	3576	11272	1470438	0.77%
2011	721	1214	1234235	0.10%
2012	593	1829	1556276	0.12%
2013	701	1588	1583302	0.10%
2014	523	1841	1869101	0.04%
2015	1322	3567	_*	_*
2016	43	164	_*	_*
2017	732	2463	_*	_*
Mean	2,798	6,990	1,604,827	0.50%
Median	1,885	3,567	1,539,961	0.29%

Brood Year	Total Fish Salvage	Total Fish Loss	# Juvenile Released	Loss/Release
SD	3,034	7,569	236,485	0.53%
95% CI	1,463	3,648	113,982	0.26%

^{*}Data were not available, therefore, the percent loss could not be calculated.

Table 2.5.5-46. Unclipped(wild) annual juvenile CCV steelhead salvage and loss from Brood Years 1998-2017.

Brood Year	Total Fish Salvage	Total Fish Loss
1998	2211	6353
1999	3728	8299
2000	4458	8655
2001	1576	4414
2002	2146	4716
2003	1761	4087
2004	1215	2460
2005	1201	2313
2006	2756	8395
2007	970	1716
2008	360	932
2009	941	2783
2010	557	800
2011	324	517
2012	744	1600
2013	185	660
2014	43	157
2015	119	293
2016	65	193.85
2017	1119	2852
Mean	1324	3110
Median	1045	2387
SD	1226	2854
95% CI	574	1336

Table 2.5.5-47. Estimated annual loss of CCV steelhead (based on the salvage-density method) for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario. There are specific loss thresholds for CCV steelhead from December through March and April through June 15.

Water Yeartype	Predicted loss under COS	edicted loss under COS under PA		% change	
Wet	6,560	7,988	1,428	22	
Above Normal	12,558	14,489	1,932	15	
Below Normal	10,188	12,056	1,867	18	
Dry	9,743	12,478	2,735	28	
Critical	5,158	7,107	1,949	38	

Table 2.5.5-48. Estimated monthly loss of CCV steelhead (based on the salvage-density method) for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities, all water year types combined. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario. There are specific loss thresholds for CCV steelhead from December through March and April through June 15.

CCV steelhead										
Month	Predicted loss under COS	Predicted loss under PA	PA-COS	% change						
October	40	60	20	48						
November	14	16	2	16						
December	43	38	-5	-12						
January	1,447	1,533	86	6						
February	1,756	1,809	54	3						
March	1,995	1,880	-116	-6						
April	604	1,528	923	153						
May	354	822	467	132						
June	269	267	-1	0						
July	31	29	-1	-4						
August	3	3	0	-1						
September	4	4	0	2						

Table 2.5.5-49. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CCV steelhead for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Water Year Type	:=	: =	State Water Project	(#)	-	Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
Wet	5,440	6,692	1252 (23.0%)	1,120	1,296	177 (15.8%)
Above Normal	10,208	11,813	1605 (15.7%)	2,349	2,676	327 (13.9%)
Below Normal	7,097	8,552	1456 (20.5%)	3,092	3,503	412 (13.3%)
Dry	7,573	9,822	2249 (29.7%)	2,170	2,656	486 (22.4%)
Critical	4,102	5,694	1592 (38.8%)	1,056	1,413	357 (33.8%)

Table 2.5.5-50. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CCV steelhead for the February 5, 2019, PA and COS scenarios at the SWP/CVPexport facilities – Wet water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	1=		Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	40	60	20 (48.5%)	0	0	0
November	11	13	2 (16.7%)	3	3	0 (12.2%)
December	38	33	-5 (-12.4%)	5	5	0 (-7.0%)
January	1,253	1,338	85 (6.8%)	194	194	0 (0.1%)
February	1,507	1,578	71 (4.7%)	249	231	-18 (-7.1%)
March	1,600	1,494	-106 (-6.6%)	395	386	-9 -2.4%)
April	465	1,246	781 (168.0%)	139	282	143 (102.3%)
May	297	699	401 (135.0%)	57	123	66 (115.4%)
June	217	219	2 (1.0%)	52	48	-3 (-6.7%)
July	4	4	0(2.3%)	26	25	-1 (-5.0%)
August	3	3	0 (-1.4%)	0	0	0
September	4	4	0 (1.7%)	0	0	0
Annual Average	5,440	6,692	1,252 (23.0%)	1,120	1,296	177 (15.8%)

Table 2.5.5-51. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CCV steelhead for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Above Normal water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	± :	-	State Water Project	-	-	Central Valley Project
#	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	4	5	1 (32.5%)	0	0	0
November	29	35	6 (20.3%)	7	6	-1 (-12.6%)
December	303	304	0 (0.1%)	31	31	0 -0.5%)
January	2,796	3,345	550 (19.7%)	1,014	1,101	87 (8.5%)
February	4,618	4,755	137 (3.0.%)	768	775	7 (0.9%)
March	1,978	1,886	-92 (-4.7%)	400	397	-3 (-0.8%)
April	289	979	690 (238.2%)	80	223	143 (178.1%)
May	130	437	307 (236.0%)	42	137	95 (228>7%)
June	53	60	7 (13.0%)	7	6	-1 (-10.8%)
July	8	8	0 (6.1%)	2	2	0 (-3.4%)
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	10,208	11,813	1,605 (15.7%)	2,349	2,676	327 (13.9%)

Table 2.5.5-52. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CCV steelhead for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities –Below Normal water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	=	Ē	State Water Project	9.	. 	Central Valley Project
-1-	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	113	103	-10 (-9.0%	8	7	-1 (-7.6%)
January	331	386	55 (16.7%)	63	68	5 (8.3%)
February	4,324	5,208	885 (20.5.%)	2,164	2,456	292 (13.5%)
March	2,227	2,577	349 (15.7%)	782	801	19 (2.4%)
April	47	122	74 (155.8%)	42	81	40 (94.4%)
May	54	157	103 (188.7%)	34	90	57 (167%)
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	7,097	8,552	1,456 (20.5%)	3,092	3,503	412 (13.3%)

Table 2.5.5-53. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CCV steelhead for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities –Dry water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	2:	-	State Water Project	2	20	Central Valley Project
- -	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	2	3	1 (32.4%)	0	0	0
November	43	52	9 (21.0%)	2	2	0 (-7.7%)
December	93	94	0 (0.5%)	3	2	0 (-9.0%)
January	621	647	25 (4.1%)	73	74	1 (1.0%)
February	2,437	2,911	474 (19.4%)	702	894	192 (27.4%)
March	3,539	4,552	1,012 28.6%)	1,121	1,296	175 (15.6%)
April	634	1,162	527 (83.2%)	243	339	97 (39.8%)
May	177	370	193 (108.7%)	20	39	19 (94.5%)
June	14	22	8 (59.8%)	7	10	3 (39.8%)
July	12	10	-2 (-13.1%)	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	7,573	9,822	2,249 (29.7%)	2,170	2,656	486 (22.4%)

Table 2.5.5-54. Estimated entrainment index (number of fish lost, based on historical loss data and the salvage-density method) of juvenile CCV steelhead for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Critical water year type. Revised loss thresholds in the June 14, 2019 PA are expected to limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project			Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	196	200	3 (1.6%)	234	239	5 (2.0%)
February	2,944	3,975	1,031 (35.0%)	624	885	261 (41.8%)
March	644	924	280 (43.4%)	141	221	79 (56.1%)
April	187	348	161 (86.1%)	46	54	8 (17.2%)
May	111	194	83 (74.5%)	10	14	4 (39.6%)
June	10	43	33 319.6%)	0	0	0
July	9	10	1 (9.7%)	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	4,102	5,694	1,592 (38.8%)	1,056	1,413	357 (33.8%)

Table 2.5.5-55. Estimated entrainment index (number of fish salvaged, based on salvage data and the salvage-density method) of juvenile sDPS green sturgeon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Wet water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	(#/)	-	Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	3	5	2 (48.5%)	8	8	0
November	6	7	1 (16.7%)	4	4	0
December	0	0	0	10	9	-1 -7.0%)
January	2	2	0	0	0	0
February	42	44	2 (4.7%)	0	0	0
March	4	3	0	0	0	0
April	0	0	0	2	3	2 (102.3%)
May	0	0	0	5	11	6 (115.4%)
June	2	2	0	7	7	0 (-6.7%)
July	1	1	0	20	19	-1 (-5.0%)
August	30	30	0	5	5	0 (0.4%)
September	18	18	0	12	13	0 (3.7%)
Annual Average	107	112	5 (4.4%)	73	80	7 (9.3%)

Table 2.5.5-56. Estimated entrainment index (number of fish salvaged, based on salvage data and the salvage-density method) of juvenile sDPS green sturgeon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Above Normal water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario.

Month		-	State Water Project			Central Valley Project
))	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	2	3	1 (19.7%)	0	0	0
February	6	6	0 (3.0%)	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	4	4	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	12	12	1 (7.1%)	0	0	0

Table 2.5.5-57. Estimated entrainment index (number of fish salvaged, based on salvage data and the salvage-density method) of juvenile sDPS green sturgeon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Below Normal water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario.

Month	-	-	State Water Project	-	_	Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	0	0	0	0	0	0

Table 2.5.5-58. Estimated entrainment index (number of fish salvaged, based on salvage data and the salvage-density method) of juvenile sDPS green sturgeon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Dry water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario.

Month	-	2	State Water Project	-	24	Central Valley Project
77 ₄₇ 1	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	19	21	2 (8.7%)
November	1	1	0 (21.0%)	25	23	-2 (-7.7%)
December	16	16	0 (0.5%)	8	7	-1 (-9.0%)
January	0	0	0	3	4	0 (1.0%)
February	0	0	0	0	0	0
March	4	5	1 (28.6%)	0	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	21	22	1 (6.6%)	55	55	-1 (-1.6%)

Table 2.5.5-59. Estimated entrainment index (number of fish salvaged, based on salvage data and the salvage-density method) of juvenile sDPS green sturgeon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – Critical water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario.

Month	-		State Water Project	-	-	Central Valley Project
	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	4	4	0 (2.0%)
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	3	4	1 (17.2%)
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
Annual Average	0	0	0	8	9	1 (8.7%)

Table 2.5.5-60. Estimated entrainment index (number of fish salvaged, based on historical salvage dat and the salvage-density methoda) of juvenile sDPS green sturgeon for the February 5, 2019, PA and COS scenarios at the SWP/CVP export facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable to the COS scenario.

Water Year Type	2	-	State Water Project	-	2	Central Valley Project
-	cos	PA	PA – COS (% change)	cos	PA	PA v COS (% change)
Wet	107	112	5 (4.4%)	73	80	7 (9.3%)
Above Normal	12	12	1 (7.1%)	0	0	0 (0.0%)
Below Normal	0	0	0 (0.0%)	0	0	0 (0.0%)
Dry	21	22	1 (6.6%)	55	55	-1 (-1.6%)
Critical	0	0	0 (0.0%)	8	9	1 (8.7%)

2.5.5.14 Summary Tables of Stressors for each Project Component

Table 2.5.5-61. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the Delta Cross Channel Gate Operations.

Species	Life-stage present	Timing of presence	Stressor Response		Frequency/ Exposure	Probable Fitness Change
WRCS	Adult migration or holding	Jan - June	Open DCC gates; Routing into alternative migratory paths	Increased straying into the Mokelumne River system due to open gates, delay behind closed gates	Annual, gates normally open Oct – Nov, Gates operated infrequently between Dec and Jan	Delayed migration
CV SRCS CCV SH		Jul - May				•
sDPS GS		All Year				
Winter- run Chinook salmon	Juveniles, migration/ rearing	Oct-April	Open DCC gates: Routing into Delta interior Increased transit times to western Delta Altered downstream hydrodynamics Higher vulnerability to entrainment at SWP and CVP fish collection facilities	Increased mortality, low survival	Annual, gates normally open Oct –Nov. Gates operated infrequently between Dec and Jan, closed Feb 1 – May20, 50% of juvenile population migrates into Delta by end of January	Reduced survival
CV Spring- run Chinook salmon	Juveniles, migration/ rearing	Dec - May	Open DCC gates: Routing into Delta interior increased transit times to western Delta Altered downstream hydrodynamics	Increased mortality, low survival	Annual, gates normally open Oct – Nov. Gates operated infrequently between Dec and Jan, closed Feb 1 – May20. 5% of	Reduced survival

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
CCV Steelhead	Juveniles, migration/	Nov - June	Higher vulnerability to entrainment at SWP and CVP fish collection facilities Open DCC gates: Routing into	Increased mortality, low	YOY SR migrate into Delta by end of January, higher percentage of yearlings Annual, gates normally open	Reduced survival
	rearing		Delta interior increased transit times to western Delta Altered downstream hydrodynamics Higher vulnerability to entrainment at SWP and CVP fish collection facilities	survival	Oct – Nov. Gates operated infrequently between Dec and Jan, closed Feb 1 – May20. 25 - 50% of juvenile steelhead migrate into Delta by end of January,	
sDPS Green Sturgeon	Juveniles, migration/ rearing	Year round	Open DCC gates: Routing into Delta interior increased transit times to western Delta Altered downstream hydrodynamics Higher vulnerability to entrainment at SWP and CVP fish collection facilities	Movement into and through the interior Delta	Annual,Gates open mid- June through the end of Nov. operated infrequently between Dec and Jan, closed Feb 1 – May20	Uncertain impacts to fitness due to extended rearing behavior in the Delta

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon
CV SRCS = Central Valley spring-run Chinook salmon
CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-62. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the North Bay Aqueduct Operations.

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
WRCS	Juveniles, migration/ rearing	Oct - April	Routing, delayed migration	Increased mortality, lower survival	Year round pumping/ low exposure risk due to location	Minimal Reduction in survival
CV SRCS CCV SH		Dec - May Nov - June				
WRCS CV SRCS	Juveniles, migration/ rearing	Oct - April Dec - May	Entrainment/impingement on fish screens	Injury and mortality	Year round pumping/ low exposure risk due to location	Minimal change in fitness
CCV SH sDPS GS		Nov - June All Year				
WRCS	Juveniles, migration/ rearing	Oct - April	Impingement/ capture during weed removal	Injury and mortality	Infrequent cleaning/ seasonal	Minimal change in fitness
CV SRCS CCV SH		Dec - May Nov - June				
sDPS GS WRCS	Juveniles, migration/ rearing	All Year Oct - April	Entrainment during sediment cleaning	Injury and mortality	Infrequent cleaning/ seasonal	Minimal change in fitness
CV SRCS CCV SH	rearing	Dec - May Nov - June			scasonai	nuess
sDPS GS		All Year				
sDPS Green Sturgeon	Juveniles, Delta rearing	Year round presence	Routing	Delayed migration to western Delta	Year round pumping/ low exposure risk due to location	Minimal Reduction in survival

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon

CV SRCS = Central Valley spring-run Chinook salmon CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-63. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the Contra Costa Water District – Rock Slough Operations.

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
WRCS CV SRCS	Juveniles, migration/ rearing	Oct - April	Routing, delayed migration	Increased mortality, lower survival	Year round pumping/ low exposure risk due to location	Minimal Reduction in survival
CCV SH		Nov - June				
sDPS Green Sturgeon	Juveniles, Delta rearing	Year round presence	Routing	Delayed migration to western Delta	Year round pumping/ low exposure risk due to location	Minimal Reduction in survival

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon
CV SRCS = Central Valley spring-run Chinook salmon
CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-64. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the Extension of the Water Transfer Window.

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
Winter-run Chinook salmon	Juveniles, migration/ rearing	October through April	Transit times	Reduced transit times in riverine sections of the mainstems	Perhaps annually during October and November, uncertain volumes and duration	Minimal benefit to fitness and survival
CV Spring- run Chinook salmon	Juveniles, migration/ rearing	December through May	Transit times	Reduced transit times in riverine sections of the mainstems	Perhaps annually during October and November, uncertain volumes and duration and fish presence in November (yearlings)	Minimal benefit to fitness and survival
CCV Steelhead	Adult, upstream migration	July through May	Low Autumn flows	Increased flows may stimulate upstream migration and reduce straying	Perhaps annually during October and November, uncertain volumes and duration of transfer flows	Increased fitness
CCV Steelhead	Juveniles, migration/ rearing	Nov - June	Transit times	Reduced transit times in riverine sections of the mainstems	Perhaps annually during October and November, uncertain volumes and duration	Minimal Increased fitness
sDPS Green Sturgeon	Adult migration/ holding	Year round	Low Autumn Flows	Stimulate fall downstream migration	Perhaps annually during October and November, uncertain volumes and duration	Uncertain benefits

*Export effects will be addressed in the South Delta Export Operations.

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon = Central Valley spring-run Chinook salmon CV SRCS CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-65. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the Suisun Marsh Salinity Control Gate Operations/ Roaring River Food Distribution Studies.

Species	Life-stage present	Timing of presence	Str	essor	Response	Frequency/ Exposure	Probable Fitness Change
WRCS	Juvenile migration/ rearing	Oct - April	•	Changes in flow	Temporary delays by closed radial gates; boat lock open	70-80 days of operation, mostly summer	Minimal change in fitness
CV SRCS		Dec - May	•	Predation	Lower survival due to predation at gates		
CCV SH		Nov - June	•	Physical barrier			
sDPS GS	1	All Year	2				
WRCS	Adult migration/ holding	Jan-June	•	Changes in flow	Temporary delays in migration, boat lock open	70-80 days of operation, mostly summer	Minimal change in fitness
CV SRCS		Jan - June	•	Physical barrier			
CCV SH	1	July - May					
sDPS GS	1	All Year	2				

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon CV SRCS = Central Valley spring-run Chinook salmon

CCV SH = California Central Valley Steelhead

= southern Distinct Population Segment of North American Green Sturgeon sDPS GS

Table 2.5.5-66. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and life-stages affected by the CVP/SWP South Delta Export Operations.

Species	Life- stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
WRCS	Juveniles, migration/	Oct - April	South Delta Exports:	Reduced survival due to export	Annual, year round	Reduced survival
CV SRCS	rearing	Dec - May	Entrainment and loss	operations	operations	and fitness
CCV SH		Nov - Jun	Altered hydrodynamics			
sDPS GS	-	All Year	Predation			
WRCS	Juveniles, migration/ rearing	Oct - April	Predator Studies: • Capture in sampling gear	Injury or death from contact with sampling gear	January through June-	Minimal reduced survival
CV SRCS		Dec - May			multi-year study,	and fitness
CCV SH		Nov - Jun	• Predation		infrequent sampling	
sDPS GS		All Year				
WRCS	Juveniles, migration/ rearing	Oct - April	CO ₂ Injector Use • Hypercapnia	Fish narcosis due to hypercapnia/ potential death of	Late fall – early summer	Increased facility efficiency
CV SRCS		Dec - May	Reduced predator population	small fish	when listed salmonids present	resulting in increased survival of
CCV SH		Nov - Jun	population		Parameter	entrained fish, some reduced
sDPS GS		All Year				fitness/ survival due to CO ₂ exposure
WRCS	Juveniles, migration/ rearing	Oct - April	Shift in Operations from SWP to CVP –	More fish entrained at CVP, reduced	Annual when listed fish present	Increased survival
CV SRCS		Dec - May	Exports/ entrainmentPredation	predation impact from CCF	and CVP capacity available	
CCV SH	-	Nov - Jun			The state of the s	e.

Species	Life- stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
sDPS GS		All Year				
sDPS GS	Juveniles, migration/ rearing Adults	All year	Aquatic weed control CCF in summer Herbicide exposure Water quality	Reduced physiological fitness, potential death	Potentially annually during summer	Reduced fitness

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon
CV SRCS = Central Valley spring-run Chinook salmon
CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-67. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the South Delta Agricultural Barriers Operations.

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
CV SRCS	Adult/ migratory	Dec - May	Increased transit timePhysical	Migratory delays and physiological	Annually from May to Nov	Reduced fitness and potentially
CCV SH		Nov - Jun	barriers to movementReduced water	decline		spawning fitness
sDPS GS		All Year	qualityAlteredhydrodynamics			
WRCS	Juveniles, migration/ rearing	Oct - April	Increased transit time	Reduced survival and increased	Annually juveniles exposed	Reduced fitness and potentially
CV SRCS		Dec - May	 Physical barriers to movement 	transit through time	during the May	spawning fitness
CCV SH		Nov - Jun	Reduced water quality	the south Delta waterways	through early June period	
sDPS GS		All Year	PredationAlteredHydrodynamics			

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon
CV SRCS = Central Valley spring-run Chinook salmon
CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-68. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the Fall Delta Smelt Habitat Operations.

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
WRCS	Juveniles, migration/ rearing	Oct - April	• Flow conditions • Water	Changes in upstream water quality conditions	Above normal and Wet years in	Variable responses depending on implementation.
CV SRCS		Dec - May	Temperature • Water Quality	below reservoirs Changes in	September and October	
CCV SH		Nov - Jun	• Exports	migratory behavior • Changes in Delta		
sDPS GS		All Year		Hydrodynamics related to outflow and exports		
CCV SH	Adult migration	Jul - May	Flow ConditionsExports	Upstream releases stimulate upstream migration	Above normal and Wet years in September and October	Variable response depending on implementation.
sDPS GS	Adult migration	All Year	Flow conditions	Upstream releases stimulate downstream migration	Above normal and Wet years in September and October	Variable response depending on implementation.

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon
CV SRCS = Central Valley spring-run Chinook salmon
CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-69. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the Sacramento Deep Water Ship Channel Food Study.

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
WRCS	Juveniles, migration/ rearing	Oct - April	Passage impediment Barrier	Fish movements blocked by closed boat locks.	Unknown how frequently boat locks would be	Uncertain due to lack of clarity on timing and duration of
CV SRCS		Dec - May	Angling pressure Water temperatures	Angler bycatch	opened for food studies	lock operations resulting in variable responses.
CCV SH		Nov - Jun	 Water quality Flow conditions Entrainment Predation 	Altered flows and operations of locks may decrease water quality		
sDPS GS		All Year		High predator population of non-native fish present in ship channel		
WRCS	Adult migration and holding	Jan - June	 Passage impediment Barrier Angling pressure 	Fish movements blocked by closed boat locks.	Unknown how frequently boat locks would be	Uncertain due to lack of clarity on timing and duration of
CV SRCS		Jan - June	Water temperatures Flow conditions	Anglers/ hooking mortality	opened for food studies	lock operations resulting in variable responses.
CCV SH		Jul - May	Water quality	Altered flows and operations of locks may decrease water quality		
sDPS GS		Al Year	Entrainment Ship traffic	Ship strikes to gsDPS green Sturgeon		

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon
CV SRCS = Central Valley spring-run Chinook salmon
CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

Table 2.5.5-70. Summary of Life Stage, Timing, Stressor, Response and Frequency table for species and lifestages affected by the North Delta Food Subsidies/ Colusa Drain Studies.

Species	Life-stage present	Timing of presence	Stressor	Response	Frequency/ Exposure	Probable Fitness Change
sDPS GS	Juvenile migration/ rearing	All Year	Contaminants – pesticides, heavy metals Low Dissolved Oxygen Increased Water temperature Nutrients	Exposure to contaminants, low DO, increased water temperatures and high nutrient loads may decrease physiological status. In extreme exposures possibly morbidity or death	July through September for multiple study years. If successful perhaps annually.	Minimal change in fitness
SDPS GS	Adult migration/ holding	July - May All Year	Contaminants – pesticides, heavy metals Low Dissolved Oxygen Increased	Reduced physiological status and growth	July through September for multiple study years. If successful perhaps	Minimal change in fitness
			Water temperature • Nutrients		annually	

Abbreviations:

WRCS = Sacramento River winter-run Chinook salmon
CV SRCS = Central Valley spring-run Chinook salmon
CCV SH = California Central Valley Steelhead

sDPS GS = southern Distinct Population Segment of North American Green Sturgeon

2.5.5.15 Revisions to OMR Management

Table 2.5.5-71. Summary of key changes in the OMR management component of the June 14, 2019 final PA in comparison to the February 5, 2019, PA

Element	February 5, 2019 (original) PA	June 14, 2019 (final) PA					
Onset of OMR Management							
OMR limit associated with "First Flush" Turbidity event	-3,500 cfs (PA text) -2,000 cfs (PA Modeling in Appendix D of BA)	-2,000 (PA text) No new modeling.					
Additional Real-Time OMR Restrictions							
OMR limit associated with Turbidity Bridge Avoidance	-5,000 cfs (PA text) -2,000 cfs (PA Modeling in Appendix D of BA)	-2,000 cfs (PA text) No new modeling.					
Wild Central Valley Steelhead Protection	OMR limit of -2,500 cfs for 5 days whenever more than 5 percent of steelhead are present in the Delta and daily loss of natural origin steelhead exceeds 10 steelhead per TAF.	No daily loss trigger; replaced with revised steelhead loss threshold.					
Loss threshold (cumulative): for specified populations	None identified	Cumulative historical loss from 2010-2018 (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.					
Salvage or Loss Thresholds (annual): Wild winter-run Chinook salmon (loss)	1 percent of the JPE (genetically confirmed or 2 percent based on length at date)	90% of the greatest annual loss that occurred in the historical record from 2010 through 2018 (December-March): 1.17% of the JPE					

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Element	February 5, 2019 (original) PA	June 14, 2019 (final) PA
Salvage or Loss Thresholds (annual): spring-run Chinook salmon (loss)	1 percent of the JPE (or 0.5 percent of spring-run surrogates for yearlings)	None identified
Salvage or Loss Thresholds (annual): Hatchery winter- run Chinook salmon (loss)	None identified	90% of the greatest annual loss that occurred in the historical record from 2010 through 2018: 0.116% of the hatchery JPE
Salvage or Loss Thresholds (annual): wild steelhead (salvage in original PA; loss in final PA)	3,000 (salvage)	90% of the greatest annual loss that occurred in the historical record from 2010 through 2018 for two separate periods: December-March (loss of 1,414 steelhead) and April-June 15 (loss of 1,552 steelhead)
Salvage or Loss Thresholds (annual): Green sturgeon (salvage)	100	None identified
Salvage or Loss Thresholds (annual): OMR action response when observed loss exceeds average historic loss	None identified	Reclamation and DWR will review information and seek technical assistance from NMFS
Salvage or Loss Thresholds (annual): OMR action response when observed loss	-3,500 cfs OMR limit until the species-specific offramp ¹⁶ is met.	-3,500 cfs OMR limit until the species-specific offramp is met, unless Reclamation

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¹⁶ In the PA and throughout this table, "species-specific offramp" refers to the conditions that would end OMR management for a particular species. Specifically, the June 14, 2019 PA defines the end of OMR management as follows: "OMR criteria may control operations until June 30 (for Delta Smelt and Chinook salmon), until June 15 (for steelhead/rainbow trout), or when the following species-specific off ramps have occurred, whichever is earlier:

Delta Smelt: when the daily mean water temperature at CCF reaches 25°C for 3 consecutive days;

Salmonids:

when more than 95 percent of salmonids have migrated past Chipps Island, as determined by their monitoring working group, or

after daily average water temperatures at Mossdale exceed 72°F for 7 days during June (the 7 days do not have to be consecutive)."

Element	February 5, 2019 (original) PA	June 14, 2019 (final) PA					
exceeds 50% of the loss threshold		and DWR determine that further OMR restrictions are not required based on risk assessment. Reclamation and DWR will seek technical assistance from NMFS.					
Salvage or Loss Thresholds (annual): OMR action response when observed loss exceeds 75% of the loss threshold	-2,500 cfs OMR limit until the species-specific offramp is met.	-2,500 cfs OMR limit until the species-specific offramp is met, unless Reclamation and DWR determine that further OMR restrictions are not required based on risk assessment. Reclamation and DWR will seek technical assistance from NMFS.					
	Storm Related OMR Flexibility						
Conditions when storm flex would not occur	Additional real-time OMR restrictions in effect	Additional real-time OMR restrictions in effect, plus some additional limits					
End of OMR Management							
Date-based offramp for Chinook salmon and steelhead	June 30 for Chinook salmon and steelhead	June 30 for Chinook salmon, June 15 for steelhead					

2.5.6 Stanislaus River (East Side Division)

Operational effects of dams on rivers and the species that live in them are multi-faceted and complex. This analysis focuses on key elements of Reclamation's operation of New Melones Dam, and related dams of the East Side Division (see area map in Figure 2.5.6-1 and deconstructed action in

So, for example, if, after conducting a risk assessment, Reclamation and DWR implemented a -3,500 cfs OMR limit action on June 3 after exceeding 50% of the April-June 15 steelhead loss threshold, that OMR action would not extend past June 15 due to the date-based offramp for OMR management for steelhead. Note that the -5,000 cfs OMR limit will be in effect until offramps for *all* species are met.

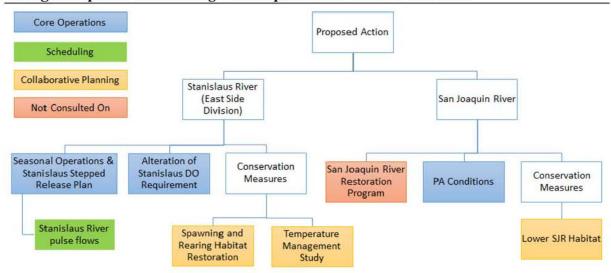


Figure 2.5.6-2), that may affect life history stages of CCV steelhead and any CV spring-run Chinook salmon when they are in the Stanislaus River.

Stanislaus River **NEW MELONES** NEW MELONES DAM TULLOCH DAM GOODWIN DAM Legend Dams/ Pumping Plants Temperature or Dissolved Oxygen Compliance 10 Miles

Figure 2.5.6-1. Area map of key locations in the CVP East Side Division (modified from Figure 1-7 of ROC on LTO BA).

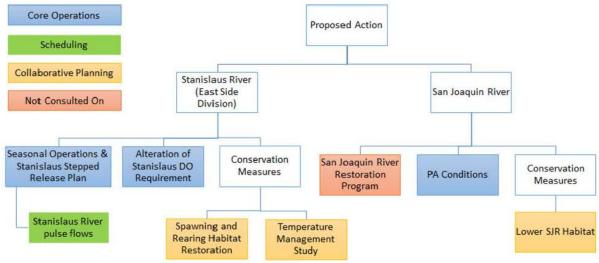


Figure 2.5.6-2. Deconstruction of the action for Stanislaus and San Joaquin rivers (East Side Division).

In the San Joaquin River basin, the southern Sierra Nevada diversity group, there have been reports of adult "spring-running" Chinook salmon returning to San Joaquin River tributaries, February through June (Franks 2015, National Marine Fisheries Service 2016a), or present in the Stanislaus River in spring and summer (Kennedy and Cannon 2002), indicating that a population (or populations) do(es) exist. Additionally, in 2014, spring-run Chinook salmon were reintroduced into the San Joaquin River; these reintroduced fish have been designated as a nonessential experimental population under ESA section 10(j) in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River (78 FR 79622 2013). Just recently, eight returning SJRRP adults were confirmed in the restoration area, marking 65 years since CV spring-run Chinook salmon have completed their life cycle in this location (preliminary data Reclamation). The analysis of effects to species in the Stanislaus River focuses on effects to particular life history stages of CCV steelhead and (for informational purposes) any CV spring-run Chinook salmon that may be present. Note that in the CV spring-run Chinook salmon Integration and Synthesis Section (Section 2.8.3), NMFS discusses the San Joaquin experimental population and associated 4(d) rule with respect to findings under this Opinion.

Due to a continued high demand for limited water supply in the Central Valley, numerous stressors continue to affect the viability of salmonid populations. Table 2.5.6-1 provides a summary of which stressors from the "Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead" (National Marine Fisheries Service 2014b) will be analyzed under each PA component within this effects analysis for the Stanislaus River (East Side Division).

Table 2.5.6-1. Summary of which stressors from the "Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead" (NMFS 2014) will be analyzed under each PA component within this effects analysis for the Stanislaus River (East Side Division). An "X" indicates the stressor will be analyzed for at least one life-stage and species and a "-" indicates that the stressor is not applicable for a particular PA component.

W			53		1000000	Vi-	35		S		3	12	5	25.2	20
Project Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
2.5.7.1 Seasonal Operations and Stanislaus Stepped Release Plan	х	-	х	-	х	х	х	х	- 9	х	х	х	-	х	х
2.5.7.2 Alteration of Stanislaus DO requirement	-	-		х	-	-	Ä	-		3	-	х	e	х	-
2.5.7.3.1 Conservation Measures – Spawning and Rearing Habitat Restoration	72			·	21	x	х	х	27	х	x	-	-	х	
2.5.7.3.2 Conservation Measures – Temperature Management Study	i.e.	-	X		х	-	=	1=	Œ	-	-	х	300	х	

A recent discussion of stressors in the Stanislaus River and potential effects is provided in Stanislaus River Scientific Evaluation Process (SEP) Team (2019). Proposed operations will continue to affect flows and water temperatures in a way that will continue to negatively affect salmonids present in the Stanislaus and San Joaquin rivers.

2.5.6.1 Seasonal Operations and Stanislaus Stepped Release Plan

Reclamation operates the CVP East Side Division for flood control, agricultural water supplies, hydroelectric power generation, fish and wildlife protection, and recreation. The New Melones

Dam operates in conjunction with Tulloch Reservoir and Goodwin Dam on the Stanislaus River. Goodwin Dam, completed in 1912, is an impassible barrier to upstream fish migration at RM 59. Water is released from New Melones to satisfy senior water right entitlements, instream and Vernalis salinity standards specified under D-1641 and D-1422, CDFG fish agreement flows, CVP water contracts and b(2) or CVPIA 3406(b)(3). Reclamation proposes to operate New Melones Reservoir to provide minimum releases at Goodwin Dam according to a Stepped Release Plan (SRP) with annual release volumes by year type as shown in Table 2.5.6-2. A summary of the PA is provided in Appendix A2 of this Opinion, with additional description provided in Appendix A (Facility Descriptions and Operations) of the ROC on LTO BA. The daily flow schedules (one for each water year type) of the proposed SRP are provided in Appendix K of this Opinion. When compared to minimum daily flow schedules from Appendix 2-E of the NMFS 2009 Opinion, the minimum daily flow schedules for the New Melones SRP are identical for critical, dry, and below normal year types; above normal and wet year types follow minimum daily flow schedules for below normal and above normal year types from Appendix 2-E of the NMFS 2009 Opinion, respectively (Table 2.5.6-2). Notably, Reclamation also proposes to determine year type using the "60-20-20" Index for the San Joaquin Valley Water Year Hydrologic Classification (based on the current water year's hydrology and the previous year's index), rather than the New Melones Index (NMI; based on end-of-February New Melones storage and March-September inflow to New Melones) used currently.

Table 2.5.6-2. New Melones Stepped Release Plan annual releases by year type (based on San Joaquin Valley "60-20-20" Index). (Source: ROC on LTO BA: Modification of Table 4-14)

Water Year Type (60-20-20 Index)	SRP Annual Release (TAF)	Equivalent to Appendix 2-E schedule from listed year type (New Melones Index)
Critical	184.3	Critical
Dry	233.3	Dry
Below normal	344.6	Below normal
Above normal	344.6	Below normal
Wet	476.3	Above normal

Reclamation proposes to implement the SRP similar to current operations, in that seasonal flow volumes (as defined in the default daily flow schedules) may be shaped to meet specific biological objectives. The Stanislaus Watershed Team (successor to the Stanislaus Operations Group), which will include stakeholders (unlike the Stanislaus Operations Group, which includes only agency members) will provide input on shaping seasonal flows.

Releases at Goodwin Dam to the Stanislaus River under the COS (current modeling representation of project operations at the time of consultation) or PA may exceed the proposed minimum fishery flows in Appendix 2-E (for COS) or the SRP (for PA) for a variety of reasons, including flood control, reservoir storage management, and other regulatory requirements. Some key uncertainties in the PA for the East Side Division relate to Reclamation's assumptions about changes to regulatory requirements or agreements that are in flux or may not be fully within Reclamation's discretion to change. The assumptions in question include:

<u>Vernalis flows in D-1641:</u> Modeling for the COS scenario assumes only the February through June "base flow" requirements at Vernalis (which might result in releases into the Stanislaus River above Appendix 2-E flows), and does not include the October and spring pulse flows at Vernalis in D-1641¹⁷. Modeling for the PA scenario does not assume any Vernalis flow standard at any time of the year¹⁸; Vernalis flows are simply the results of upstream contributions, including the SRP.

Because of the SWRCB's efforts to update the Bay Delta Water Quality Control Plan, there is uncertainty about what Vernalis flow requirements will be in January 2020. NMFS analyzed the effects as modeled.

<u>Vernalis Electrical Conductivity (EC) in D-1641:</u> Modeling for the COS assumes the Vernalis EC standards in D-1641 (which might result in releases into the Stanislaus River above Appendix 2-E flows). Modeling for the PA scenario does not assume any Vernalis EC standard¹⁹; Vernalis EC is simply the result of upstream contributions, including the SRP.

Because of the SWRCB's efforts to update the Bay Delta Water Quality Control Plan, there is uncertainty about what Vernalis EC requirements will be in January 2020. NMFS analyzed the effects as modeled.

Ripon Dissolved Oxygen (DO) standard in D-1422: One component of the PA is to shift the compliance location for the DO Standard (in D-1422) about 30 river miles upstream (from Ripon to Orange Blossom Bridge) during the summer. Modeling for the COS and

¹⁷ Reclamation's perspective on the Vernalis flow requirements is provided in an April 12, 2018, letter from Reclamation to the SWRCB:

 $https://www.waterboards.ca.gov/waterrights/water_issues/programs/compliance_monitoring/sacramento_sanjoaquin/docs/2018/04122018_usbrltr.pdf$

¹⁸ In a consultation meeting on May 24, 2019, Reclamation clarified that some Vernalis flow standard may be in place by January 2020, but that the CVP contribution would be considered met by Stanislaus operations under the PA.

¹⁹ In a consultation meeting on May 24, 2019, Reclamation clarified that some Vernalis EC standard may be in place by January 2020, but that the CVP contribution would be considered met by Stanislaus operations under the PA.

PA do not differ (though the narrative acknowledges that flows might occasionally be lower during the summer due to this component of the PA). Neither NMFS nor Reclamation has the authority to approve a shift in this DO compliance location, so NMFS assumes that Reclamation will obtain any necessary approvals for this change before implementation of this PA component. The range of effects prior to implementation of the shift in DO compliance location is within the range of effects evaluated assuming the compliance location is changed, so coverage is provided both before and after the necessary approvals are obtained.

"1987 Agreement²⁰" between Reclamation and (then) California Department of Fish and Game: Modeling assumptions include the "1987 Agreement" as a factor in the COS scenario (though the modeling assumes that the Appendix 2-E flows from the NMFS 2009 Opinion satisfy the "1987 Agreement"). The PA scenario assumes that the SRP supersedes the "1987 Agreement." NMFS analyzed the effects as modeled and defers to Reclamation and the California Department of Fish and Wildlife to resolve the issue.

2.5.6.1.1 Review of Stanislaus River Flows under the PA

Dam operations typically alter the downstream hydrograph from the unimpaired hydrograph, and this is true of the CVP's New Melones Dam, most notably by the reduction in annual peak flows due to capture of winter and snowmelt flood flows. Schneider et al. (2000) summarized the flattening of the hydrograph in both wet and dry years after construction of New Melones Dam. In wet year conditions, annual peak flows of 25,000 cfs to 30,000 cfs were reduced to <5,000 cfs. In dry year conditions, annual peak flows of 7,000 cfs to 8,000 cfs were reduced to <1,500 cfs (Figure 2.5.6-3).

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²⁰ The 1987 Agreement is an agreement between California Department of Fish and Game and the United States Department of the Interior Bureau of Reclamation regarding interim instream flows and fishery studies in the Stanislaus River below New Melones Reservoir.

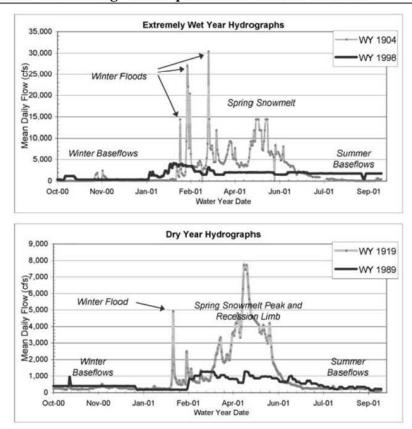


Figure 2.5.6-3. Annual comparison of Wet and Dry year hydrographs before (1904 and 1919) and after (1989 and 1998) construction of New Melones Dam. (Source: Figure 4 in Schneider et al. 2000).

Further discussion of changes to the flow regime of the Stanislaus River after construction of New Melones Dam is provided in Kondolf et al. (2001). While the hydrologic summary in Figure 2.5.6-3 does not include post-New Melones Dam operations under the NMFS 2009 Opinion, both current and proposed operations on the Stanislaus River show similar hydrologic characteristics, i.e. a flattened hydrograph with limited winter and springtime flows. While the average monthly flow output from CalSimII does not capture peak daily flow, model outputs for the PA scenario and COS scenario show that average monthly flows exceed 2,000 cfs only in March of Wet water year types and never exceed 750 cfs in Critical water year types (Table 2.5.6-3). The daily flow schedules in the SRP (Appendix K) include annual peak flows of 725 cfs (Critical), 1,000 cfs (Dry), 2,000 (Below Normal and Above Normal), and 3,000 cfs (Wet).

Table 2.5.6-3. Exceedance table of average modeled monthly flow in the Stanislaus River below Goodwin Dam for the PA scenario and COS scenario. (Source: ROC on LTO BA: Table 37-3 from Appendix D, Attachment 3-2)

Table 37-3. Stanislaus River Flow below Goodwin, Monthly Flow

	Monthly Flow (CFS)													
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
Probability of Exceedance														
10%	837	290	306	358	897	1,648	1,633	1,929	1,100	429	392	390		
20%	797	200	218	232	405	1,521	1,553	1,555	1,089	318	300	300		
30%	774	200	200	232	282	440	1,553	1,294	940	300	283	250		
40%	774	200	200	226	236	200	1,400	1,242	853	300	283	250		
50%	774	200	200	226	236	200	1,400	1,242	363	275	283	250		
60%	636	200	200	219	229	200	812	918	363	265	283	249		
70%	636	200	200	219	229	200	767	705	294	265	283	249		
80%	578	200	200	214	221	200	767	631	262	265	283	249		
90%	577	200	200	213	215	200	504	547	255	265	263	249		
Long Term Full Simulation Period ³	723	278	367	519	593	754	1,159	1,124	680	395	362	351		
Water Year Types b.c														
Wet (23%)	859	532	863	999	1,193	2,014	1,536	1,691	1,140	716	639	692		
Above Normal (24%)	728	205	212	664	676	645	1,224	1,146	959	353	292	267		
Below Normal (10%)	752	200	202	282	346	365	1,454	1,201	475	269	285	256		
Dry (16%)	677	200	200	234	313	200	1,030	930	375	276	277	245		
Critical (27%)	614	200	236	227	255	234	742	700	282	272	264	231		

						Monthly Flo	ow (ICFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance		10-10-01			C 1000 - 1							
10%	797	200	306	552	2,259	1,528	1,572	1,555	940	300	300	300
20%	797	200	200	232	294	1,521	1,553	1,555	940	300	300	300
30%	774	200	200	230	236	675	1,553	1,242	363	265	283	250
40%	774	200	200	226	229	200	1,400	1,242	363	265	283	250
50%	774	200	200	226	229	200	1,400	1,242	363	265	283	250
60%	636	200	200	226	229	200	972	819	255	265	283	249
70%	636	200	200	219	221	200	767	631	255	265	283	249
80%	577	200	200	213	214	200	466	400	200	200	200	200
90%	577	200	200	213	214	200	460	400	200	200	200	200
Long Term Full Simulation Period [®]	718	272	341	549	722	762	1,147	1,036	566	378	338	339
Water Year Types B.c												
Wet (23%)	854	508	735	1,003	1,750	2,189	1,475	1,665	1,499	834	625	691
Above Normal (24%)	774	202	223	694	695	577	1,571	1,255	363	265	283	258
Below Normal (10%)	774	200	202	546	528	247	1,610	1,242	363	265	283	250
Dry (16%)	626	200	209	224	228	200	825	655	256	255	270	241
Critical (27%)	578	200	236	220	222	218	501	445	200	200	200	198

						Monthly Fk	ow (ICFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	-41	-90	0	194	1,362	-121	-62	-375	-160	-129	-92	-90
20%	0	0	-18	0	-111	0	0	0	-149	-18	0	(
30%	0	0	0	-2	-46	236	0	-52	-577	-35	0	(
40%	0	0	0	0	+7	0	0	0	-490	-35	0	
50%	0	0	0	0	-7	0	0	0	0	-10	0	
60%	0	0	0	6	0	0	160	-99	-108	0	0	
70%	0	0	0	0	4	0	0	-75	-38	0	0	(
80%	-1	0	0	-1	-7	0	-300	-231	-62	-05	-83	-49
90%	0	0	0	0	-1	0	-44	-147	-65	-65	-83	-49
Long Term Full Simulation Period	4	-6	-26	31	129	8	-11	-87	-114	-17	-24	-13
Water Year Types b,c												
Wet (23%)	-6	-24	-128	4	557	175	-81	-26	359	118	-14	
Above Normal (24%)	46	-3	11	31	20	-68	347	109	-596	-88	-9	.45
Below Normal (10%)	22	0	0	264	183	-118	156	41	-111	-4	-2	4
Dry (16%)	-51	0	9	-10	-86	0	-205	-274	-119	-21	-6	4
Critical (27%)	-36	0	0	-7	-33	-15	-241	-255	-82	-72	-64	-33

b As defined by the San Juaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRC8 D-1641, 1999)

c These results are displayed with calendar year - year type sorting.
d All scenarios are simulated at ELT IE any Long-Termi (Or with 2005 climate change and 15 cm sea level rise of These are draft results meant for qualitative analysis and are subject to revision.
Their Melionis brecasts are used as the basis of malter operations.

2.5.6.1.2 Analysis of Proposed Changes in Operations and Year Type Method under the PA

To understand the effects of the proposed changes in operations (due to the SRP and assumptions about other regulatory requirements) and changes in year type method, NMFS assessed the year type distributions for the year type method and operations combinations in Table 2.5.6-4.

Table 2.5.6-4. Comparison of year type method and operations combinations.

Name of scenario	Operations scenario	Year type method	Comments
COS-NMI	Current Operations (with Appendix 2- E flow schedules)	New Melones Index (for operations and year type assignment in modeling)	Current Operations Scenario
PA-60-20-20	Proposed Action (with Stepped Release Plan flow schedules)	San Joaquin 60-20-20 Index (for operations and year type assignment in modeling)	Proposed Action Scenario

Table 2.5.6-5 describes how the distribution of year types changes under different year typemethod and operations combinations. There are more Critical, Above Normal, and Wet water year types and fewer Dry and Below Normal water year types in the PA scenario (PA-60-20-20) compared to the COS scenario (COS-NMI).

Table 2.5.6-5. Distribution of year types under different year type method and operations combinations.

P	anel A	Count of water ye	ars in each yeartyp
Y	eartype	COS-NMI	PA-60-20-20
5	Critical	18	24
4	Dry	20	10
3	Below Normal	21	9
2	Above Normal	14	20
1	Wet	9	19
4	Total	82	82
P	anel B	Percent of water ye	ears in each yearty
Y	eartype	COS-NMI	PA-60-20-20
5	Critical	22	29
4	Dry	24	12
3	Below Normal	26	11
2	Above Normal	17	24
1	Wet	11	23
	Total	100	100

Because hydrology is the same; a change in PA-60-20-20 compared to COS-NMI is likely to be caused by a COMBINED change in the year type method and storage condition due to differing operations under the PA.

Table 2.5.6-6 describes results of the comparison between the PA and COS in terms of "year type differential."

Table 2.5.6-6. Results of the comparisons between PA and COS in terms of "year type differential." Critical, Dry, Below Normal, Above Normal, and Wet water year types are represented as 5, 4, 3, 2, and 1, respectively. For example, a year with a PA-60-20-20 year type of Above Normal (3), and a COSNMI year type of Dry (4) would result in a "year type differential" of 3 - 4 = -1.

Panel A	Count of water years
Yeartype differential	PA 60-20-20 minus COS NMI
-3	4
-2	6
-1	18
0	38
1	14
2	2
3	0
Total	82
min	-3
max	2
Panel B	Percent of water years (in 82 year
Yeartype differential	PA 60-20-20 minus COS NMI
-3	5
-2	7
-1	22
0	46
1	17
2	2
3	0
Total	100

General conclusions based on Table 2.5.6-6 include:

PA-60-20-20 to COS-NMI

- Comparing PA-60-20-20 to COS-NMI controls only for hydrology and thus represents
 the effect of the COMBINED change in the year type method and storage condition due
 to differing operations under the PA.
- The combined effect is asymmetric, with 28 of 82 years (34 percent) being classified as
 wetter year types (which might trigger a higher flow schedule per the SRP) and 16 of 82
 years (20 percent) being classified as drier water year types (which might trigger a lower
 flow schedule per the SRP).
- Because the SRP "downshifts" the two highest flow schedules in the NMFS 2009 Opinion's Appendix 2-E (i.e., PA's Wet water year type flow schedule is the same as the NMFS 2009 Opinion's Above Normal water year type flow schedule and PA's Above Normal water year type flow schedule is the same as the NMFS 2009 Opinion's Below Normal water year type flow schedule), a shift from Below Normal in COS to Above Normal in the PA (or from Above Normal in COS to Wet in the PA) doesn't actually trigger a flow schedule with higher releases.

The PA's required minimum flows are lower in Above Normal and Wet water year types (based on SRP tables), so would be lower overall even if year type distribution was unchanged. The COS and PA's modeled flows (see Table 2.5.6-3), however, are more similar than might be expected based on this year type analysis and the required fishery minimum flow schedules (Appendix 2-E in the COS; SRP in the PA). The largest changes are that April and May flows during Dry and Critical water year types are about 200-250 cfs lower in the PA compared to the COS (probably due to the assumption that no Vernalis flow requirement is in effect in the PA, compared to an assumption of base Vernalis flows February through June in the COS). June flows are also lower in the PA except in Wet water year types. The greatest reduction in June flows in seen in Above Normal water year types; this is likely the signal from the SRP's implementation of the Appendix 2-E Below Normal flows in an Above Normal water year type. NMFS's interpretation of why larger changes are not observed in the PA flows compared to the COS flows is that in many Above Normal and Wet water year types (the years in which required flows in the PA are, in some months, lower than required flows in the COS), New Melones flood operations occur more often during February, March, and June in the PA, and thus modeled flows reflect releases higher than minimum flows, particularly during Wet water year types. Another reason is that the assumptions in the COS include only base Vernalis flows February to June, and not any of pulse flow elements in D-1641 (in October or mid-April to mid-May), so the PA assumption of no Vernalis flow requirements represents less of an operational change than if the COS assumed the D-1641 Vernalis pulse flow requirements.

2.5.6.1.3 Review of Stanislaus River Temperatures under the PA

Modeled water temperatures show much cooler conditions in Goodwin Canyon below Goodwin Dam (RM 59, Table 2.5.6-7) than at Orange Blossom Bridge (Table 2.5.6-8), about 11 river miles downstream of Goodwin Dam at RM 47. There is little difference in temperatures between the PA and COS at Goodwin Dam; water temperatures there are largely driven by the temperature of water released from New Melones Dam and any warming in Tulloch Reservoir and Goodwin Reservoir (with residence time not generally expected to change between the COS and PA scenarios). Air temperatures will warm or cool water between Goodwin Dam and Orange Blossom Bridge, and this warming or cooling is buffered at higher flows due to increased thermal mass. Results show that temperatures at Orange Blossom Bridge are often slightly warmer in the PA, particularly in June and July.

Table 2.5.6-7. Exceedance table of average modeled monthly average temperature in the Stanislaus River below Goodwin Dam for the PA scenario and COS scenario. Interpretation of year type differences from these tables is complicated by the fact that both PA and COS flows are summarized by the 60-20-20 year type, even though COS flows are modeled based on the NMI year type. (Source: ROC on LTO BA: Table 22-3 from Appendix D, Attachment 3-2)

Table 22-3. Stanislaus River below Goodwin Dam, Monthly Temperature

					Mont	hly Temper	ature (DEG	-F)				
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	60.7	59.2	54.6	51.1	50.8	51.9	53.1	54.1	55.6	57.6	58.3	60.1
20%	58.0	56.5	53.3	50.3	50.2	51.4	52.4	53.6	54.8	55.9	56.5	57.4
30%	56.1	55.5	52.5	49.7	49.5	50.8	52.1	53.0	54.0	55.2	55.8	56.4
40%	55.5	54.8	51.9	49.3	48.9	50.6	51.7	52.8	53.7	54.6	55.2	55.7
50%	55.0	54.2	51.6	48.9	48.8	50.3	51.4	52.6	53.3	54.4	54.8	55.3
60%	54.5	54.0	51.2	48.4	48.4	50.0	51.0	52.1	52.7	53.5	54.2	54.6
70%	54.0	53.5	51.0	48.0	47.9	49.8	50.6	51.8	52.5	53.2	53.9	54.2
80%	53.5	52.9	50.4	47.3	47.4	49.0	50.1	51.5	52.0	52.6	53.3	53.7
90%	52.4	52.1	49.8	46.4	46.7	48.3	49.2	50.6	50.8	51.5	52.2	52.5
Long Term												
Full Simulation Period ³	56.0	54.9	51.8	48,7	48.7	50.2	51,3	52.5	53.5	54.6	55.3	56.1
Water Year Types b,c												
Wet (23%)	52.9	52.4	50.6	47.9	47.7	49.2	50.0	51.3	51.6	52.2	52.8	53.0
Above Normal (24%)	55.2	54.5	51.7	48.4	48.0	49.6	50.6	51.9	52.5	53.5	54.5	55.2
Below Normal (10%)	54.9	54.2	51.5	48.4	48.7	50.0	51.3	52.1	52.9	54.1	54.7	55.1
Dry (16%)	56.7	55.6	52.2	49.2	49.2	50.9	51.9	52.8	53.9	55.1	56.0	56.7
Critical (27%)	59.4	57.3	52.9	49.7	49.9	51.5	52.7	54.3	56.0	57.5	58.2	59.5

					Mont	hly Temper	atune (DEG	i-F)				
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance	24014000	National Contract	200.00	124.54.00	514170	le-SteV	(*)OLUM	55000	and the	A-100 (A00)	311/2/3	10-1
10%	58.8	57.1	53.7	50.7	50.6	52.0	53.0	54.3	55.6	57.0	57.5	58.1
20%	56.4	55.7	53.1	50.2	50.1	51.4	52.5	53.5	54.8	55.7	56.3	56.7
30%	55.6	54.7	52.5	49.5	49.4	50.9	52.1	53.1	54.1	55.1	55.5	56.1
40%	55.D	54.3	51.8	49.1	49.1	50.6	51.8	52.9	53.7	54.7	55.0	55.3
50%	54.7	53.9	51.4	48.9	48.8	50.3	51.4	52.6	53.2	54.2	54.7	55.0
60%	54.3	53.7	51.2	48.4	48.4	50.0	51.2	52.2	52.7	53.7	54.3	54.6
70%	53.9	53.3	50.8	48.0	47.9	49.8	50.8	52.0	52.4	53.3	53.8	54.2
80%	53.4	52.8	50.3	47.4	47.5	49.0	50.1	51.5	51.9	53.0	53.3	53.7
90%	52.3	52.2	49.5	46.9	47.0	48.5	49.4	50.8	51.1	51.8	52.5	52.5
Long Term					11101111							
Full Simulation Period ^a	55.3	54.4	51.7	48.7	48.8	50.3	51.3	52.5	53.4	54.4	55.2	55.6
Water Year Types b,c	1000000											
Wet (23%)	53.0	52.6	50.7	47.9	47.9	49.1	50.0	51.4	51.7	52.4	53.0	53.2
Above Normal (24%)	55.4	54.3	51.6	48.5	48.2	49.7	50.6	51.9	52.5	53.8	54.7	55.5
Below Normal (18%)	54.4	53.8	51.3	48.5	48.7	50.1	51.6	52.2	52.9	54.0	54.5	54.7
Dry (16%)	55.6	54.7	51.9	49.0	49.1	50.9	51.9	52.8	53.9	54.8	55.3	55.8
Critical (27%)	57.4	56.3	52.7	49.6	49.8	51.6	52.7	54.0	55.6	56.7	57.8	58.1

					Mont	hly Temper	ature (DEG	-F)				
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	-1.9	-2.0	-0.9	-0.4	-0.2	0.1	-0.1	0.2	0.0	-0.6	-0.8	-2.0
20%	-1.6	-0.8	-0.2	0.0	-0.1	0.0	0.1	-0.1	-0.1	-0.1	-0.2	-0.7
30%	-0.5	-0.8	0.0	-0.1	-0.1	0.1	0.0	0.0	0.1	0.0	-0.3	-0.3
40%	-0.5	-0.4	-0.1	-0.2	0.1	0.0	0.1	0.1	0.1	0.0	-0.3	-0.4
50%	-0.3	-0.3	-0.1	0.1	-0.1	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.3
60%	-0.2	-0.3	-0.1	0.0	0.0	0.0	0.2	0.2	0.0	0.2	0.0	0.0
70%	-0.1	-0.1	-0.2	0.0	-0.1	0.0	0.2	0.1	-0.1	0.1	0.0	0.0
80%	-0.1	-0.1	0.0	0.1	0.1	-0.1	-0.1	0.0	-0.1	0.4	-0.1	0.0
90%	-0.1	0.1	-0.2	0.4	0.4	0.2	0.2	0.2	0.3	0.3	0,3	0.0
Long Term												
Full Simulation Period ^a	-0.7	-0.5	-0.2	0.0	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.4
Water Year Types b,o												
Wet (23%)	0.2	0.2	0.1	0.0	0.2	-0.1	0.0	0.1	0.1	0.1	0.1	0.2
Above Normal (24%)	0.2	-0.2	-0.1	0.1	0.2	0.1	0.0	0.1	0.0	0.4	0.3	0.3
Below Normal (16%)	-0.4	-0.4	-0.2	0.0	0.0	0.1	0.3	0.1	0.0	-0.1	-0.2	-0.4
Dry (16%)	-1.1	-0.9	-0.3	-0,2	-0.1	0.0	0.0	0.0	0.0	-0.3	-0.7	-0.9
Critical (27%)	-2.0	-1.0	-0.3	-0.1	0.0	0.1	0.0	-0.3	-0.5	-0.7	-0.4	-1.4

a Based on the 82-year simulation period.

As defined by the San Josephin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999)

c These results are displayed with collendar year - year type sorting.
d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 olimate change and 15 cm sea level rise.

e These are draft results meant for qualitative analysis and are subject to revision. I New Melones forecasts are used as the basis of water operations.

Table 2.5.6-8. Exceedance table of average modeled monthly average temperature in the Stanislaus River at Orange Blossom Bridge for the PA scenario and COS scenario. Interpretation of year type differences from these tables is complicated by the fact that both PA and COS flows are summarized by the 60-20-20 year type, even though COS flows are modeled based on the NMI year type. (Source: ROC on LTO BA: Table 23-3 from Appendix D, Attachment 3-4)

Table 23-3. Stanislaus River at Orange Blossom Bridge, Monthly Temperature

					Mont	hly Temper	ature (DEC	LF)				
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance	-		0.00				7.7			7.7		
10%	61.6	58.7	53.4	51.3	52.5	55.8	55.2	57.7	63.7	65.5	65.4	64.
20%	59.3	56.9	52.6	50.8	51.7	55.1	54.8	56.8	62.4	64.6	64.2	63.3
30%	57.5	56.2	52.2	50.1	51.2	54.6	54.1	55.9	61.6	64.1	63.4	62.0
40%	56.8	55.0	51.5	49.6	50.7	54.0	53.7	55.3	60.6	63.7	62.9	61.
50%	56.4	54.9	51.0	49.1	50.4	53.8	53.1	55.0	59.3	63.2	62:5	61.3
60%	55.8	54.5	50.7	48.8	50.1	53.2	52.7	54.4	56.6	62.6	62.2	60.7
70%	55.2	54.1	50.5	48.3	49.6	52.1	52.2	53.9	55.9	62.1	61.9	60.
80%	54.9	53.7	50.1	47.9	49.2	51.0	51.9	53.6	55.3	61.5	61.5	59.5
90%	54.0	52.7	49.7	47.1	48.4	49.6	50.8	52.6	54.4	58.6	59.8	58.
Long Term												
Full Simulation Period	57.2	55.3	51.4	49.2	50.4	53.2	53.2	55.1	59.0	62.9	62.7	61.5
Water Year Types ^{b,c}												
Wet (23%)	54.3	53.4	50.5	48.7	49.3	50.2	51.3	53.2	55.2	59.5	594.4	57.1
Above Normal (24%)	56.6	54.9	51.2	49.0	49.9	52.7	52.4	54.6	56.3	61.9	62.2	61.
Below Normal (10%)	56.0	54.7	51.0	48.9	50.3	53.4	52.9	54.2	58.8	63.3	62.4	61.6
Dry (16%)	57.8	56.0	51.6	49.5	50.9	54.5	54.0	55.4	61.2	64.1	63.5	62.
Critical (27%)	60.5	57.2	52.2	49.8	51.6	55.2	55.2	57.4	63.4	65.9	65.5	64.6

					Mont	hly Temper	ature (DEG	LF)				
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance			10/2	14,111	1977/199		100			1000	10,000	
10%	59.7	57.0	52.7	51.1	52.6	55.7	56.3	58.6	65.2	67.8	67.2	64.5
20%	58.0	56.1	52.5	50.5	51.9	55.1	55.6	58.1	64.6	66.5	65.6	63.2
30%	57.2	55.5	52.0	50.0	51.3	54.7	54.6	56.7	63.3	65.4	64.7	62.6
40%	56.6	54.9	51.5	49.5	50.9	54.3	53.8	55.8	61.9	64.1	63.1	62.0
50%	56.2	54.6	51.0	49.1	50.5	53.7	52.9	54.8	60.0	63.5	62:7	61.2
60%	55.8	54.4	50.6	48.9	50.1	53.1	52.5	54.3	59.3	63.2	62.1	60.8
70%	55.1	53.9	50.4	48.4	49.5	51.9	52.0	54.0	58.7	62.8	61.9	60.2
80%	54.7	53.5	50.0	47.9	49.3	50.6	51.4	53.4	56.2	61.9	61.6	60.0
90%	53.9	53.2	49.7	47.4	48.5	49.4	50.7	52.8	54.7	60.9	60.4	58.3
Long Term												
Full Simulation Period ^a	56.7	55.0	51.2	49.2	50.5	53.2	53.3	55.4	60.3	63.8	63.2	61.5
Water Year Types b,c												
Wet (23%)	54.5	53.6	50.6	48.7	49.3	49.9	51.4	53.3	54.7	59.7	59.7	58.0
Above Normal (24%)	56.7	54.8	51.1	49.1	50.0	52.9	51.9	54.1	59.3	63.2	62.6	61.5
Below Normal (10%)	55.6	54.4	50.9	48.8	50.2	53.5	52.8	54.2	59.4	63.4	62.3	60.9
Dry (16%)	57.0	55.3	51.3	49.4	51.1	54.5	54.3	56.3	62.6	64.6	63.3	61.9
Critical (27%)	58.8	56.4	52.0	49.7	51.8	55.4	55.9	58.5	65.0	67.4	66.9	64.5

					Mont	hly Temper	ature (DEG	(F)				
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance ^a												
10%	-1.9	-1.7	-0.7	-0.2	0.1	-0.1	1.0	0.9	1.5	2.4	1.8	-0.
20%	-1.3	-0.9	-0.1	-0.3	0.2	0.1	8.0	1.3	2.2	1.9	1.4	-0.
30%	-0.3	-0.6	-0.2	-0.1	0.1	0.1	0.5	0.7	1.7	1.3	1.2	0.
40%	-0.3	-0.1	0.0	-0.1	0.1	0.3	0.1	0.5	1.3	0.4	0.2	0.
50%	-0.2	-0.2	-0.1	0.0	0.1	0.0	-0.2	-0.1	6.8	0.3	0.1	0.
60%	-0.1	-0.2	-0.1	0.1	0.0	-0.1	-0.2	-0.1	2.7	0.6	-0.1	0.
70%	-0.2	-0.2	0.0	0.0	-0.1	-0.2	-0.2	0.0	2.8	0.7	0.1	-0.
80%	-0.1	-0.1	-0.1	0.0	0.1	-0.4	-0.5	-0.2	0.9	0.3	0.1	.0.
90%	-0.1	0.5	-0.1	0.3	0.1	-0.2	-0.1	0.2	0.2	2,3	0.6	0.
Long Term												
Full Simulation Period ^a	-0.6	-0.3	-0.1	0.0	0.1	0.0	0.1	0.3	1.3	0.9	0.5	0.
Water Year Types b,c												
Wet (23%)	0.1	0.2	0.1	0.0	0.0	-0.4	0.0	0.1	-0.5	0.2	0.3	0.
Above Normal (24%)	0.1	-0.1	-0.1	0.1	0.2	0.2	-0.5	-0.5	3.0	1.4	0.4	0.
Below Normal (10%)	-0.4	-0.3	-0.1	-0.1	-0.1	0.1	-0.1	0.0	8.6	0.1	-0.1	-0
Dry (16%)	-0.9	-0.7	-0.3	-0.1	0.2	0.0	0.3	0.9	1.4	0.5	-0.2	-0
Critical (27%)	-1.7	-0.8	-0.2	-0.1	0.1	0.1	0.7	1.1	1.6	1.5	1.4	-0

a Based on the 82-year simulation period.

b As defined by the San Joaquin Valley 60-20-20 Indiex Water Year Hydrologic Classification (SWRCB D-1641, 1999)

c These results are displayed with calendar year - year type coding.

4AB occanica are simulated at ELT (Early Long-Term (CD with 2005 climate change and 15 cm sea level rise.

These are define fault meant for qualifiers analysis and are subject to revision.

New Miclores forecasts are used as the basic of water operations.

Modeled temperatures are likely cooler than will be realized under actual operations based on a comparison of model results under the COS to recent measured temperatures on the Stanislaus River. For example, the COS scenario modeling results in Table 2.5.6-7 indicate that average monthly temperatures at Goodwin Dam exceed 54°F 50 percent of the time in July, 60 percent of the time in August, and 70 percent of the time in September. However, actual temperatures from 2009 to 2018 at Goodwin Dam (Figure 2.5.6-4) show that even minimum daily water temperatures exceeded 54°F for most of the summer in most years of that 10-year period, except for 2011 and 2017, both wet years with high summertime releases. This snapshot of recent temperatures compared to modeled temperatures under the climate change scenario is intended as a screening-level check on the modeled results. NMFS acknowledges that differences between modeled and recent temperatures could be due to differences in the frequency of hydrology and meteorology in the full CalSimII period and the 2009 to 2018 period.

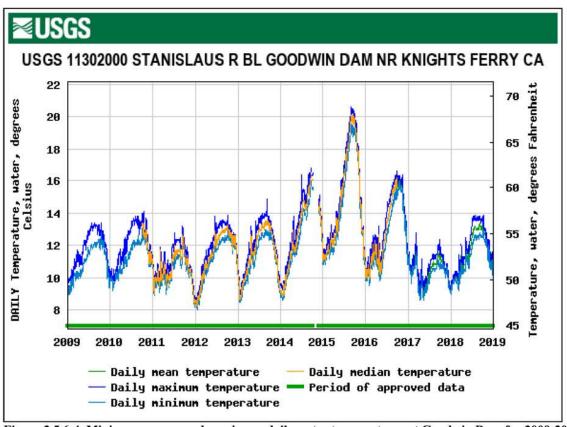


Figure 2.5.6-4. Minimum, mean, and maximum daily water temperatures at Goodwin Dam for 2009-2018. (Source: USGS gage 11302000, National Water Information System: https://waterdata.usgs.gov)

2.5.6.1.4 Review of Stanislaus River floodplain inundation under the PA

The construction of New Melones Dam reduced the frequency and extent of overbank flooding which, in combination with channel incision and the geomorphic effects of sediment starvation below dams, has isolated floodplains from the river channel, leading to the loss of important habitats and ecological functions (Schneider et al. 2000). While no specific floodplain inundation targets are in the PA, floodplain inundation in the PA can be evaluated as a function of the modeled flows under the PA. There are some minor decreases in inundated habitat on the Stanislaus River in the PA compared to the COS (Table 37-3 in the ROC on LTO BA), primarily in May and June. Because these estimates are based on average monthly flow output from CalSimII, these results are used as a screening tool to compare the potential for changes to rearing habitat. Realized flows will likely show greater variability with higher peaks (and thus more inundated acres during peak flows) and perhaps somewhat lower base flows (and thus possibly fewer inundated acres during base flows).

Table 2.5.6-9. Exceedance tables of inundated floodplain acres on the Stanislaus River under the PA and COS scenarios. (Source: Supplemental modeling provided by Reclamation in support of the ROC on LTO BA)

COSS												
Probability of												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10%		-				-	_	-		-		0
20%							-		0	0		(
30%	-									0		
40%	-						_		2	0		
50%							_		2			
60%									10	1		0
70%	8	_	_		_	_	_	_	11	1		
80%			_				-		24	1	-	1
90%			_	1	-	132			28	3		2
Mean	9			36	_				21	10		9
PA20												
Probability of	r		-	1.00 mg/s	- 1		Lesson .					2000
Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10%									0			
20%	5											
30%	- 6	_	-									
40%									0			
50%									2			0
60%									2			
70%	8		0	0	0			40			0	
80%		3 0	0	0		108			11	1	1	1
90%		3 0	1	7	259	126	118	114	11	1	1	1
Mean		9	15	39	60	57	65	47	24	15	7	9
PA20 minus C	055											
Probability of												
Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
10%	(-					0
20%		+		_	-		-		0			-
30%		-		_			_		0			
40%		_							-1	0		
50%												
60%												- 0
70%					_				-10	0		
80%		_	_			_	_	_	_	0	_	- (
90%	-	1	_		_	-	_	-	-12	-2		-1
Mean 90%	- (3					-17	-2		-1

Reclamation provided supplemental information on WUA for CCV steelhead fry and juveniles in various reaches of the Stanislaus River, and additional information on rearing habitat as a function of Stanislaus River flow is provided in Bowen et al. (2012). The PA has the potential to reduce inundated habitat during base flows, which would affect species and their critical habitat.

2.5.6.1.5 CCV Steelhead Exposure, Response, and Risk

2.5.6.1.5.1 CCV Steelhead Exposure

For the purposes of this analysis, "exposure" is defined as the temporal and spatial co-occurrence of a CCV steelhead life stage and the stressors associated with the PA. CCV steelhead exhibit

very diverse life histories, and adults and juveniles might be present in the Stanislaus River at any time of year. Since some components of the PA occur year round, CCV steelhead may be affected by the action whenever they are present in the Stanislaus River. The most likely windows of CCV steelhead exposure are summarized in Figure 2.5.6-5.

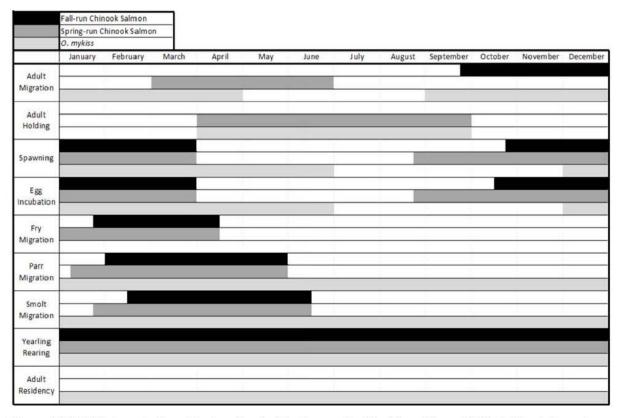


Figure 2.5.6-5. Timing of salmonid migration by life stage on the Stanislaus River; CCV steelhead shown in light gray (O. mykiss in legend) (Source: Excerpt of Figure 8 of SEP Group 2019)

For this analysis, the following life history timing is assumed:

- Spawning: December February
- Egg incubation to fry emergence: December June
- · Juvenile rearing: year round
- Juvenile migration: Primarily February May
- Smoltification: January June
- Adult migration: October March

The CCV steelhead adult immigration life stage occurs throughout the entire lower Stanislaus River. Based on reports that "young trout began to emerge from the gravel at the upper river sites

by April" (Kennedy and Cannon 2002), it is reasonable to conclude that most spawning occurs from Goodwin Dam (RM 59) to Knights Ferry (RM 54) with some spawning possible downstream to Orange Blossom Bridge near Oakdale (RM 47). The juvenile life stage occurs throughout the entire river, with rearing generally occurring in the vicinity of the upstream areas used for spawning. Observations during 2005 to 2007 snorkel surveys indicate that young CCV steelhead had the highest densities in September to October and April to July, and were most abundant in the upper and middle reaches of the river (Kennedy (2008); Figure 2.5.6-6, Figure 2.5.6-7). Young salmon and young and yearling trout were found in significantly higher densities in experimental sites where gravel had been placed in the river to create riffle habitat, which indicates that experimental sites create beneficial habitat for all young salmonids.

Steelhead 0+ Density

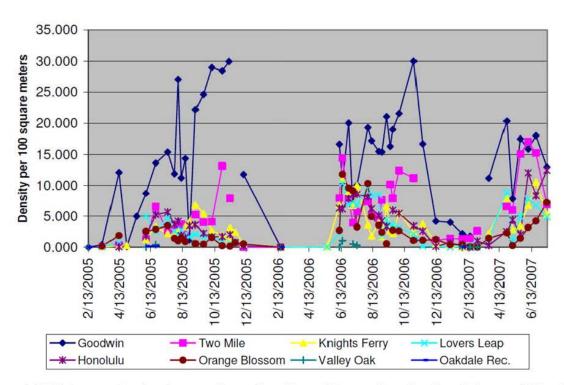


Figure 2.5.6-6. Average density of young-of-year *O. mykiss* at eight sampling sites from February 2005 to July 2007. [Source: Figure 6 in Kennedy (2008)]

Steelhead 1+ Density

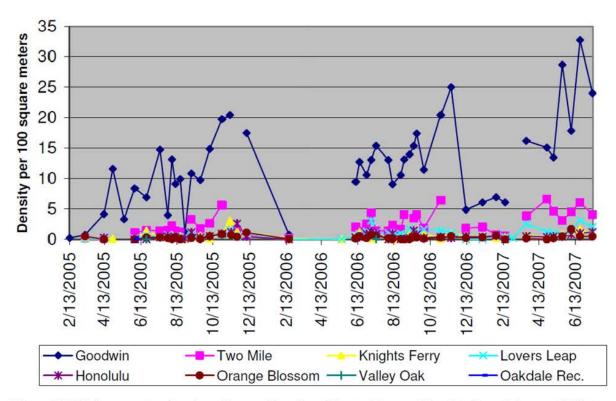


Figure 2.5.6-7. Average density of yearling or older *O. mykiss* at eight sampling sites from February 2005 to July 2007. [Source: Figure 7 in Kennedy (2008)]

There are no temperature control devices on any of the East Side Division facilities, so the only mechanism (aside from occasional flexibility to release from the gates at Tulloch Dam and the rare flexibility to use the low-level outlet at New Melones Dam) for temperature management is direct flow management. While it can take a lot of water to buffer temperature exceedances of long duration and large magnitude, less water would be required to buffer temperature exceedances of short duration and low magnitude. However, the PA does not commit to any temperature criteria for the Stanislaus River. As described above, CCV steelhead will be subjected to occasional sublethal and lethal temperature effects in the Stanislaus River from the egg through smolt stages and potentially as adults.

Aceituno (1993) applied the instream flow incremental methodology to the Stanislaus River between Riverbank and Goodwin Dam (24 river miles) and determined that flows of 200 cfs provided maximum WUA for steelhead spawning. The SRP flow schedules have minimum flows of at least 200 cfs from October through April in all water year types except Critical water

year types. The modeling results show that flows will not drop below 200 cfs, even in June through September of Critical water year types (Table 2.5.6-3), as a result of DO requirement.

Because the existing dams prevent access to historical habitat, the proposed operations of the dams control the quality and quantity of available alternative habitat below Goodwin Dam and the suitability of the physical conditions to support CCV steelhead at various life history stages. Survival or growth of CCV steelhead may be affected by operations of the East Side Division in the following ways:

- Operational releases control extent of cool water habitat available below Goodwin Dam.
- Operational release levels control the quantity and functionality of instream habitat for spawning, egg incubation, juvenile rearing and smoltification.
- Operational releases are typically lower than flows under the natural hydrograph, requiring smolting juveniles to expend more energy to outmigrate and lower stream velocities increase the exposure of juveniles and smolts to predation.

The proposed operation of the East Side Division modifies the hydrograph from the unimpaired flow pattern with which CCV steelhead evolved. Such modifications may affect survival, growth, and critical habitat for CCV steelhead in the following ways:

- Peak flood flows are dampened, reducing floodplain and side-channel inundation and impairing rearing ability including production of food;
- Flow variability is muted, eliminating migratory cues that prompt migration and anadromy;
- Flow variability is muted, causing channel incision, reducing available rearing habitat, simplifying channel complexity and allowing land use encroachment into riverside habitats; and Channel forming flows are reduced or eliminated, resulting in fossilization of gravel bars and degradation of spawning habitat.

2.5.6.1.5.1 CCV Steelhead Response

Now that the potential exposure of CCV steelhead to effects of seasonal operations and the SRP has been described, the next step is to assess how these fish are likely to respond to the PA-related stressors. Life stage-specific responses to specific stressors related to the PA are summarized in

and described briefly in this section. There may be other project stressors acting on Stanislaus River CCV steelhead than those identified in

. However, this effects analysis intends to identify and describe the most important project-related stressors to these fish.

Table 2.5.6-10. The temporal and spatial co-occurrence of CCV steelhead life stages and the stressors associated with the PA component of seasonal operations and the SRP.

Life Stage/	Spawning Goodwin Dam to Orange Blossom Bridge	Egg incubation and emergence Goodwin Dam to	Orange Blossom Bridge	Egg incubation and emergence	Goodwin Dam to	Orange Blossom Bridge	Juvenile rearing	Goodwin Dam to	Orange Blossom Bridge	Juvenile rearing	7	Goodwin Dam to	Orange Blossom	Orange Blossom Bridge		250	A 288	
Life Stage	Dec-Feb	Dec-June		Dec-June			Year round			Year round				Year round, with	the same and the same	temperature	stress likely	stress likely most acute July-
Stressor	Excessive fines in spawning gravel resulting from lack of overbank flow	Excessive fines in spawning gravel resulting from lack of overbank flow		Water temperatures warmer than life history stage	requirements	***	Lack of overbank flow to	inundate rearing habitat		Reduction in rearing habitat	complexity due to reduction in	channel forming flows		End of summer water	temperatures warmer than life	history stage requirements	more requirements	motory ongo requirements
Response	Reduced suitable spawning habitat; For individual: increased energy cost to attempt to "clean" excess fine material from spawning site	Egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of other CCV steelhead or	fall-run; suppressed growth rates	Egg mortality, Embryonic deformities			Reduced food supply; suppressed growth	rates; starvation; loss to predation; poor	energetics; indirect stress effects, smaller size at time of emigration;	Reduced food supply; suppressed growth	rates; starvation; loss to predation; poor	energetics; indirect stress effects, smaller	size at time of emigration;	Metabolic stress; starvation; loss to	predation; indirect stress effects, poor		grown,	giowai,
Probable Fitness Reduction	Reduced reproductive success	Reduced survival		Reduced survival			Reduced growth rates;	Reduced survival		Reduced growth rates;	Reduced survival			Reduced growth rates;	Reduced survival			

Reduced survival; Reduced diversity	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	Suboptimal flow (March – June)	Jan-Jun	Smolt emigration Stanislaus River
Reduced diversity.	Missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress;	Water temperatures warmer than life history stage requirements (Mar - June)	Jan-Jun	Smoltification and emigration Stanislaus River at mouth
Probable Fitness Reduction	Response	Stressor	Life Stage Timing	Life Stage/ Location

Water temperature can be a stressor in the Stanislaus River, particularly in summer months. The literature and scientific basis for life stage related temperature requirements for CCV steelhead are described in Table 2.5.6-1. A summary of those requirements relevant to CCV steelhead use of the Stanislaus River is presented in

Table 2.5.6-11. Excellent discussions of temperature suitability for salmonids in this region, and summary and evaluation of water temperature conditions at finer temporal scales are provided in SEP Group (2019) and Deas (2004).

Information on maximum temperatures was not provided in the ROC on LTO BA; rather, the modeling results summarize monthly temperatures. So, this analysis evaluates modeled monthly temperatures at Orange Blossom Bridge under the PA (Table 2.5.6-8). The suitability of modeled temperatures under the PA for each CCV steelhead life stage is summarized below in

Table 2.5.6-11. However, because the modeled monthly temperatures are lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to CCV steelhead on the Stanislaus River in the vicinity of Orange Blossom Bridge. Additionally, all the temperature model outputs are based on assumptions of daily flow equivalent to the monthly CalSimII inputs, so do not fully capture the flow (and associated temperature) variability expected during real-time operations.

Table 2.5.6-11. Salmonid temperature requirements by life stage from Table 3 and Table 4 of the U.S. EPA's Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003). Temperature requirements are based on the 7-day average of the daily maximum temperature, or 7DADM. A rough evaluation of temperature suitability under the PA at Orange Blossom Bridge is provided based on monthly averages of daily average temperature; see caveats in the narrative.

Life Stage & Timing	Temperature Criterion	Rough evaluation of water temperature suitability at Orange Blossom Bridge based on monthly averages of daily average temperature rather than 7DADM
Salmon/trout	61°F	Water temperatures are generally suitable ($\leq 61^{\circ}$ F) for
juvenile rearing	7DADM	juvenile rearing during October through May, but
(year-round)		exceed 61°F in the warmest 40 percent of years in
1993		June, 80 percent of years in July and August, and 50
		percent of years in September.
Salmon/trout	64°F	Water temperatures are generally suitable ($\leq 64^{\circ}$ F) for
migration plus	7DADM	migration and non-core juvenile rearing during October
non-core juvenile		through May, but exceed 64°F in the warmest 20
rearing		percent of years in June, 40 percent of years in July, 30
(year-round)		percent of years in August, and 10 percent of years in
A Property of the Control of the Con		September.
Salmon/trout	68°F	Water temperatures are generally suitable (≤ 68°F) for
migration	7DADM	adult CCV steelhead migration into (and for kelt
(October –		outmigration from) the Stanislaus River in all months.
March)		Water temperatures approach 68°F in July and August
mas anareans 🕶 a		of the warmest 10 percent of years, but few, if any,

Life Stage & Timing	Temperature Criterion	Rough evaluation of water temperature suitability at Orange Blossom Bridge based on monthly averages of daily average temperature rather than 7DADM
		CCV steelhead are expected to be migrating in those months.
Salmon/Trout Spawning, Egg Incubation, and Fry Emergence (December – June)	55°F 7DADM ²¹	Water temperatures are generally suitable (≤ 55°F) for spawning and incubation in December, January, and February. Water temperatures exceed 55°F in the warmest 20 percent of years in March and April, 40 percent of years in May, and 80 percent of years in June. CCV steelhead that spawn later in the season, or farther downstream will have reduced or even failed reproductive success, leading to reduced productivity and also reduce diversity in life-history timing by truncating the timing and area available for successful spawning.
Steelhead Smoltification (January – June)	57°F 7DADM	This life history stage is uniquely important for the expression of anadromy in <i>O. mykiss</i> . Water temperatures are generally suitable (≤ 57°F) for steelhead smoltification in January, February, March, and April. Water temperatures exceed 57°F in the warmest 20 percent of years in May and 70 percent of years in June. The proposed operations will truncate the successful smoltification of late developing smolts.

Relative to temperatures at Orange Blossom Bridge (except during the winter when water may cool as it moves downstream), temperatures will generally be cooler at Goodwin Dam and warmer at the confluence to the San Joaquin River. Most spawning and core juvenile rearing occurs at or above Orange Blossom Bridge. CCV steelhead juveniles can likely avoid, to some degree, unsuitable rearing water temperatures at Orange Blossom Bridge by moving farther upstream, but that does reflect a reduction of suitable rearing habitat and may result in increased competition for rearing habitat and food and reductions in growth or survival. Late-spawning CCV steelhead adults can likely avoid, to some degree, unsuitable spawning water temperatures at Orange Blossom Bridge by moving farther upstream. However, because conditions are generally suitable as far downstream as Orange Blossom Bridge from December to February, eggs spawned near Orange Blossom Bridge in those months may later experience unsuitable

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²¹ Steelhead eggs incubating in the redds in the river may need colder temperatures than 55°F to have high survival. Martin et al. (2016) found strong evidence that significant thermal mortality occurred during the embryonic stage in Chinook salmon in some years due to a >5°F reduction in thermal tolerance in the field compared to laboratory studies due to differences in oxygen supply in lab and field contexts. This issue likely applies to what is known about the relationship between thermal tolerance and steelhead survival given that, like Chinook salmon, steelhead eggs incubate under the water column in spawning gravels.

water temperatures during egg incubation or as alevins that could lead to reductions in survival. CCV steelhead juveniles may be able to reach suitable smoltification temperatures in late spring upstream of Orange Blossom Bridge, but it is uncertain whether CCV steelhead juveniles rearing in the vicinity of Orange Blossom Bridge would seek cooler temperatures suitable for smoltification.

Lindley et al. (2007) has identified the need for upstream habitat for salmonids, given predicted climate change in the next century. This may be particularly relevant for CCV steelhead on the Stanislaus River where Goodwin Dam blocks all access to historical spawning and rearing habitat and where the remaining population survives as a result of dam operations in downstream reaches that are historically (and occasionally even under the PA) unsuitable habitat because of high summertime temperatures.

There are no temperature control devices on any of the East Side Division facilities, so the only mechanism (aside from occasional flexibility to release from the gates at Tulloch Dam and the rare flexibility -- during severe drought -- to use the low-level outlet at New Melones Dam) for temperature management is direct flow management. While it can take a lot of water to buffer temperature exceedances of long duration and large magnitude, less water would be required to buffer temperature exceedances of short duration and low magnitude. However, the PA does not commit to any temperature criteria for the Stanislaus River. As described above, CCV steelhead will be subjected to occasional sublethal and lethal temperature effects in the Stanislaus River from the egg through smolt stages and potentially as adults.

As noted earlier, while Reclamation provided supplemental information on WUA for CCV steelhead fry and juveniles in various reaches of the Stanislaus River, those results are not evaluated in the Opinion due to time constraints. Additional information on rearing habitat as a function of Stanislaus River flow is provided in Bowen et al. (2012).

Past operations of the East Side Division have eliminated channel forming flows and geomorphic processes that maintain and enhance CCV steelhead spawning beds and juvenile rearing areas associated with floodplains and channel complexity (Kondolf et al. 2001). Since the operation of New Melones Dam, channel-forming flows above 8,000 cfs have been reduced to zero (as intended to avoid flooding), and mobilizing flows in the 5,000 to 8,000 cfs range occur very rarely. Channel-forming flows are important to rejuvenate spawning beds and floodplain rearing habitat and to recruit allochthonous nutrients and large wood into the river. Floodplain and side channel habitats provide important juvenile refugia and food resources for juvenile salmonid growth and rearing (Sommer et al. 2001a, Sommer et al. 2005, Heady and Merz 2007, Jeffres et al. 2008).

The SRP does not propose flows above 3,000 cfs, so flows of at least 5,000 cfs under the PA will only occur during flood control.

Operations under the PA will result in continued degradation of spawning habitat and rearing habitat. Reduction and degradation of spawning gravels directly reduces the productivity of the species by reducing the amount of usable habitat area and causing direct egg mortality. Lower productivity leads to a reduction in abundance.

Muting of winter storm flows and the spring/summer snowmelt in the seasonal hydrograph reduces the frequency and magnitude of flows that may cue anadromy, cue outmigration, and support more successful outmigration by providing a "conveyance" flow that may increase

outmigration speed (or match an outmigration speed with lower energy expenditures) and survival. Zeug et al. (2014) documented a positive relationship between a survival index and flow for juvenile Chinook salmon on the Stanislaus River (Figure 2.5.6-8), based on data from rotary screw traps near Oakdale (RM 40) and Caswell (RM 8). However, a 3-year study using radio-tagged fall-run Chinook salmon on the Stanislaus River (Zeug et al. 2016) offered somewhat contrary results. The authors noted, "Flow did not have a significant effect on survival; however, because some fish exhibited holding behavior, the stationary detection models were biased toward actively migrating fish. The mobile detection models suggested that there was a greater probability of fish transitioning out of the study reach when discharge was higher, which is supported by previous studies in this reach." The study years 2012 to 2014 had relatively dry hydrology and the variation in average flows tested ranged only from 12-77 cms (424-2,719 cfs), which does not include the highest flows required under the NMFS 2009 Opinion (short periods of 5,000 cfs in Wet water year types), and is slightly short of the highest flows required under the SRP (short periods of 3,000 cfs in Wet water year types).

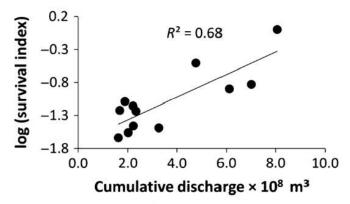


Figure 2.5.6-8. Relationship between the juvenile Chinook salmon survival index and cumulative discharge in cubic meters per second (cms) for study years 2012-2014. Cumulative discharge was calculated as the sum of daily flow at the USGS gage near Ripon from January 17 to May 27. (Source: Top left panel of Figure 3 in Zeug et al. 2014.)

2.5.6.1.5.2 CCV Steelhead Risk

Based on the effects to CCV steelhead associated with the PA component described above, fitness consequences to individuals include reduced reproductive success during spawning, reduced survival during embryo incubation, reduced survival and growth during juvenile rearing, and reduced survival and growth during smolt emigration (see

). Additionally, conditions may restrict the window of successful outmigration of individuals and, thus, reduce the diversity of outmigration timing for the population.

2.5.6.1.6 CV Spring-run Chinook Salmon Exposure, Response, and Risk

2.5.6.1.6.1 CV Spring-run Chinook Salmon Exposure

Temporal occurrence of any CV spring-run Chinook salmon that may be in the Stanislaus River is not well understood, though anecdotal information about observations of spring-running fish, adults holding over the summer, and early fry have been reported (Kennedy and Cannon 2002, Kennedy and Cannon 2005, Kennedy 2008). Based on adult and juvenile migration timing, egg incubation to fry emergence are assumed to occur from August through February and juvenile rearing from November through May for juveniles that emigrate as young-of-year; year-round for juveniles that emigrate as yearlings. The most likely windows of exposure for any CV spring-run Chinook salmon that may be in the Stanislaus River and stressors are summarized in Table 2.5.6-12. NMFS expects any CV spring-run Chinook salmon life stages that may be in the Stanislaus River would experience similar exposure as CCV steelhead with the addition of oversummering adults being exposed to a greater degree to high water temperatures.

2.5.6.1.6.2 CV Spring-run Chinook Salmon Response

Now that the potential exposure of any CV spring-run Chinook salmon that may be in the Stanislaus River to effects of seasonal operations and the SRP has been described, the next step is to assess how these fish are likely to respond to the PA-related stressors. Life stage-specific responses to specific stressors related to the PA are summarized in Table 2.5.6-12 and described briefly in this section. There may be other project stressors acting on any CV spring-run Chinook salmon that may be in the Stanislaus River than those identified in Table 2.5.6-12. However, this effects analysis intends to identify and describe the most important project-related stressors to these fish.

Table 2.5.6-12. The temporal and spatial co-occurrence of CV spring-run Chinook salmon life stages that may be in the Stanislaus River and the stressors associated with the PA component of seasonal operations and the SRP.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Spawning Goodwin Dam to Knights Ferry	Aug-Oct	Water temperatures warmer than life history stage requirements	Egg mortality, Embryonic deformities	Reduced reproductive success; Reduced survival
Spawning Goodwin Dam to Knights Ferry	Aug-Oct	Excessive fines in spawning gravel resulting from lack of overbank flow	Reduced suitable spawning habitat; For individual: increased energy cost to attempt to "clean" excess fine material from spawning site	Reduced reproductive success

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction		
Egg incubation and emergence Goodwin Dam to Knights Ferry	Aug-Feb	Reduced suitable spawning habitat	Spawning habitat not likely limited during spawning, but fall-run may superimpose redds before spring- run fry emergence	Reduced survival		
Egg incubation and emergence Goodwin Dam to Knights Ferry	ncubation and emergence Goodwin Dam to Knights Aug-Feb Aug-Feb Excessive files in spawning gravel resulting from lack of overbank flow		Egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of CCV steelhead or fall-run; suppressed growth rates	Reduced survival		
Egg incubation and emergence Goodwin Dam to Knights Ferry	incubation and emergence Goodwin Dam to Knights Water temperatures warmer than life history stage requirements		Egg mortality, Embryonic deformities	Reduced survival		
Juvenile rearing Goodwin Dam to Orange Blossom Bridge	Nov-May for YOY; year-round for yearling	Lack of overbank flow to inundate rearing habitat	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival		
Juvenile rearing Goodwin Dam to Orange Blossom Bridge	rearing Goodwin Dam to Orange Blossom Nov-May for YOY; year-round for yearling Reduction in rearing habitat complexity due to reduction in channel forming		Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival		
Juvenile rearing Knights Ferry to Orange Blossom Bridge	rearing Knights Ferry to Orange Blossom Nov-May for YOY; year-round for yearling Nov-May water temperatures warmer than life history stage		Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	Reduced growth rates; Reduced survival		

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Smolt emigration Stanislaus River	Nov-May	Suboptimal flow (March – June)	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	Reduced survival; Reduced diversity

Many of the stressors affecting any CV spring-run Chinook salmon that may be in the Stanislaus River identified in Table 2.5.6-12 are similar to those discussed for CCV steelhead in

and NMFS assumes that any CV spring-run Chinook salmon that may be in the Stanislaus River respond similarly as described for CCV steelhead unless described otherwise in this section. Water temperatures, however, are separately evaluated below since the expected spatial distribution of adults and timing of spawning through fry emergence is different for any CV spring-run Chinook salmon that may be in the Stanislaus River.

Observations of adult Chinook salmon in the Stanislaus River during the summer are generally between Goodwin Dam and Knights Ferry, though adult Chinook salmon were observed as far downstream as Orange Blossom Bridge during snorkel surveys. During the summer and fall, when spawning and egg incubation for any CV spring-run Chinook salmon that may be in the Stanislaus River is expected, water temperatures are coolest near Goodwin Dam, intermediate near Knights Ferry, and warmest at Orange Blossom Bridge. Temperature data at Knights Ferry were not summarized in Appendix D of the ROC on LTO BA, but temperature data at that location were provided in raw modeling results. Therefore, the temperature evaluation is conducted a bit differently for CV spring-run Chinook salmon than in the evaluation for CCV steelhead to incorporate data from all three locations, which represent a range of potential effects experienced by any CV spring-run Chinook salmon that may be in the Stanislaus River, dependent on their in-river distribution.

The modeling results presented below summarize monthly temperatures at Goodwin Dam, Knights Ferry, and Orange Blossom Bridge under the PA and COS, as reported in the raw modeling results provided with the ROC on LTO BA. The narrative summary focuses on the PA results. The summaries for Goodwin Dam and Orange Blossom Bridge are the same as those provided in Table 2.5.6-7 and Table 2.5.6-8. Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to any CV spring-run Chinook salmon that may be in the Stanislaus River. Additionally, all the temperature model outputs are based on assumptions of daily flow equivalent to the monthly CalSimII inputs, so do not fully capture the flow (and associated temperature) variability expected during real-time operations.

Suitable temperatures for each CV spring-run Chinook salmon life stage (with life-stage timing noted) are summarized in Table 2.5.6-13, and the evaluation of water temperatures under the PA

and COS are evaluated using these criteria at Goodwin Dam, Knights Ferry, and Orange Blossom Bridge for juvenile rearing (Table 2.5.6-14), migration plus non-core juvenile rearing (Table 2.5.6-15), migration (Table 2.5.6-16), and spawning, egg incubation, and fry emergence (Table 2.5.6-17).

Table 2.5.6-13. Salmonid temperature requirements by life stage from Table 3 and Table 4 of the U.S. EPA's Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003), along with life stage timing for any CV spring-run Chinook salmon that may be in the Stanislaus River. Temperature requirements are based on the 7-day average of the daily maximum temperature, or 7DADM.

Life Stage & Timing	Temperature Criterion
Salmon/trout juvenile rearing (year-round, including yearlings)	61°F 7DADM
Salmon/trout migration plus non-core juvenile rearing (November – May for migration; year-round for rearing of yearlings)	64°F 7DADM
Salmon/trout migration (November - May)	68°F 7DADM
Salmon/Trout Spawning, Egg Incubation, and Fry Emergence (August - February)	55°F 7DADM ²²

steelhead eggs incubate under the water column in spawning gravels.

²² Steelhead eggs incubating in the redds in the river may even need colder temperatures than 55°F to have high survival. Martin et al. (2016) found strong evidence that significant thermal mortality occurred during the embryonic stage in Chinook salmon in some years due to a >5°F reduction in thermal tolerance in the field compared to laboratory studies due to differences in oxygen supply in lab and field contexts. This issue likely applies to what is known about the relationship between thermal tolerance and steelhead survival given that, like Chinook salmon,

Table 2.5.6-14. Evaluation of water temperature suitability under the PA (panel a) and COS (panel b) for juvenile core rearing of CV spring-run Chinook salmon (Temperature criterion = 61°F 7DADM). Data are modeled monthly water temperatures (not 7DADM), by San Joaquin "60-20-20" year type, under the relevant scenario. Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to any CV spring-run Chinook salmon that may be in the Stanislaus River. Red shading indicates month/year type combinations in which monthly water temperatures exceed the temperature criterion. Juveniles may be rearing in the Stanislaus River year-round.

a) PA scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
					Goodw	in Dam						
Wet	53.0	52.6	50.7	47.9	47.9	49.1	50.0	51.4	51.7	52.4	53.0	53.2
Above Normal	55.4	54.3	51.6	48.5	48.2	49.7	50.6	51.9	52.5	53.8	54.7	55.5
Below Normal	54.4	53.8	51.3	48.7	49.0	50.3	51.7	52.3	53.0	54.1	54.6	54.9
Dry	54.8	54.1	51.4	48.5	48.8	50.7	51.7	52.6	53.7	54.5	54.8	55.1
Critical	57.5	56.4	52.8	49.7	49.8	51.5	52.7	53.9	55.5	56.7	57.8	58.2
					Knight	s Ferry						
Wet	53.4	52.8	50.6	48.0	48.2	49.3	50.4	52.0	52.6	54.8	55.1	54.7
Above Normal	55.8	54.3	51.3	48.6	48.7	50.6	51.0	52.6	54.7	56.9	57.3	57.4
Below Normal	54.7	53.8	51.1	48.7	49.4	51.3	52.0	52.9	55.1	57.3	57.1	56.8
Dry	55.2	54.1	51.1	48.5	49.3	51.7	52.4	53.7	56.6	57.6	57.3	57.0
Critical	57.9	56.3	52.5	49.6	50.3	52.6	53.6	55.3	58.7	60.3	60.8	60.2
				C	range	Blossor	n					
Wet	54.5	53.6	50.6	48.7	49.3	49.9	51.4	53.3	54.7	59.7	59.7	58.0
Above Normal	56.7	54.8	51.1	49.1	50.0	52.9	51.9	54.1	59.3	63.2	62.6	61.5
Below Normal	55.6	54.4	50.9	49.1	50.5	53.8	52.9	54.3	59.6	63 7	62.4	61.1
Dry	56.2	54.7	50.9	48.9	50.8	54.3	54.1	56.1	62.4	63.9	62.6	61.2
Critical	59.0	56.6	52.1	49.8	51.8	55.3	55.9	58.5	64.9	67.4	66.9	64.5

b) COS scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
				0	Goodw	in Dam						
Wet	52.9	52.4	50.6	47.9	47.7	49.2	50.0	51.3	51.6	52.2	52.8	53.0
Above Normal	55.2	54.5	51.7	48.4	48.0	49.6	50.6	51.9	52.5	53.5	54.5	55.2
Below Normal	54.9	54.2	51.5	48.7	49.0	50.2	51.4	52.2	53.1	54.2	54.9	55.3
Dry	55.6	54.8	51.7	48.7	49.0	50.7	51.9	52.7	53.6	54.7	55.3	55.8
Critical	59.6	57.5	53.1	49.8	49.8	51.4	52.7	54.2	55.9	57.4	58.3	59.7
					Knight	s Ferry						
Wet	53.3	52.6	50.5	48.1	48.1	49.4	50.4	51.9	52.7	54.6	54.9	54.5
Above Normal	55.6	54.5	51.4	48.5	48.5	50.5	51.1	52.7	53.7	56.3	57.0	57.0
Below Normal	55.1	54.2	51.2	48.8	49.3	51.2	51.9	52.8	54.8	57.3	57.3	57.2
Dry	55.9	54.8	51.4	48.7	49.4	51.8	52.4	53.4	56.2	57.7	57.7	57.6
Critical	59.9	57.3	52.7	49.7	50.3	52.5	53.4	55.1	58.3	60.1	60.6	61.1
				C)range	Blosson	n					
Wet	54.3	53.4	50.5	48.7	49.3	50.2	51.3	53.2	55.2	59.5	59.4	57.8
Above Normal	56.6	54.9	51.2	49.0	49.9	52.7	52.4	54.6	56.3	61.9	62.2	61.1
Below Normal	56.0	54.7	51.0	49.2	50.5	53.7	53.0	54.4	58.6	63.5	62.6	61.3
Dry	56.8	55.3	51.2	49.1	50.7	54.3	53.8	55.2	61.3	63.9	62.9	61.6
Critical	60.7	57.4	52.4	49.8	51.6	55.2	55.2	57.3	63.3	65.8	65.6	64.7

Table 2.5.6-15. Evaluation of water temperature suitability under the PA (panel a) and COS (panel b) for migration and non-core juvenile rearing of CV spring-run Chinook salmon (Temperature criterion = 64°F 7DADM). Data are modeled monthly water temperatures (not 7DADM), by San Joaquin "60-20-20" year type, under the relevant scenario. Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to any CV spring-run Chinook salmon that may be in the Stanislaus River. Red shading indicates month/year type combinations in which monthly water temperatures exceed the temperature criterion. The months of November through May are highlighted in green to indicate that migration and non-core juvenile rearing are occurring in these months; juvenile rearing may occur year-round.

a) PA scenario

ra scenario												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
					Goodw	in Dam						
Wet	53.0	52.6	50.7	47.9	47.9	49.1	50.0	51.4	51.7	52.4	53.0	53.2
Above Normal	55.4	54.3	51.6	48.5	48.2	49.7	50.6	51.9	52.5	53.8	54.7	55.5
Below Normal	54.4	53.8	51.3	48.7	49.0	50.3	51.7	52.3	53.0	54.1	54.6	54.9
Dry	54.8	54.1	51.4	48.5	48.8	50.7	51.7	52.6	53.7	54.5	54.8	55.1
Critical	57.5	56.4	52.8	49.7	49.8	51.5	52.7	53.9	55.5	56.7	57.8	58.2
					Knight	s Ferry						
Wet	53.4	52.8	50.6	48.0	48.2	49.3	50.4	52.0	52.6	54.8	55.1	54.7
Above Normal	55.8	54.3	51.3	48.6	48.7	50.6	51.0	52.6	54.7	56.9	57.3	57.4
Below Normal	54.7	53.8	51.1	48.7	49.4	51.3	52.0	52.9	55.1	57.3	57.1	56.8
Dry	55.2	54.1	51.1	48.5	49.3	51.7	52.4	53.7	56.6	57.6	57.3	57.0
Critical	57.9	56.3	52.5	49.6	50.3	52.6	53.6	55.3	58.7	60.3	60.8	60.2
				C	range	Blosson	n					
Wet	54.5	53.6	50.6	48.7	49.3	49.9	51.4	53.3	54.7	59.7	59.7	58.0
Above Normal	56.7	54.8	51.1	49.1	50.0	52.9	51.9	54.1	59.3	63.2	62.6	61.5
Below Normal	55.6	54.4	50.9	49.1	50.5	53.8	52.9	54.3	59.6	63.7	62.4	61.1
Dry	56.2	54.7	50.9	48.9	50.8	54.3	54.1	56.1	62.4	63.9	62.6	61.2
Critical	59.0	56.6	52.1	49.8	51.8	55.3	55.9	58.5	64.9	67.4	66.9	64.5

b) COS scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
Goodwin Dam													
Wet	52.9	52.4	50.6	47.9	47.7	49.2	50.0	51.3	51.6	52.2	52.8	53.0	
Above Normal	55.2	54.5	51.7	48.4	48.0	49.6	50.6	51.9	52.5	53.5	54.5	55.2	
Below Normal	54.9	54.2	51.5	48.7	49.0	50.2	51.4	52.2	53.1	54.2	54.9	55.3	
Dry	55.6	54.8	51.7	48.7	49.0	50.7	51.9	52.7	53.6	54.7	55.3	55.8	
Critical	59.6	57.5	53.1	49.8	49.8	51.4	52.7	54.2	55.9	57.4	58.3	59.7	
	Knights Ferry												
Wet	53.3	52.6	50.5	48.1	48.1	49.4	50.4	51.9	52.7	54.6	54.9	54.5	
Above Normal	55.6	54.5	51.4	48.5	48.5	50.5	51.1	52.7	53.7	56.3	57.0	57.0	
Below Normal	55.1	54.2	51.2	48.8	49.3	51.2	51.9	52.8	54.8	57.3	57.3	57.2	
Dry	55.9	54.8	51.4	48.7	49.4	51.8	52.4	53.4	56.2	57.7	57.7	57.6	
Critical	59.9	57.3	52.7	49.7	50.3	52.5	53.4	55.1	58.3	60.1	60.6	61.1	
	77			C	range	Blosson	n						
Wet	54.3	53.4	50.5	48.7	49.3	50.2	51.3	53.2	55.2	59.5	59.4	57.8	
Above Normal	56.6	54.9	51.2	49.0	49.9	52.7	52.4	54.6	56.3	61.9	62.2	61.1	
Below Normal	56.0	54.7	51.0	49.2	50.5	53.7	53.0	54.4	58.6	63.5	62.6	61.3	
Dry	56.8	55.3	51.2	49.1	50.7	54.3	53.8	55.2	61.3	63.9	62.9	61.6	
Critical	60.7	57.4	52.4	49.8	51.6	55.2	55.2	57.3	63.3	65.8	65.6	64.7	

Table 2.5.6-16. Evaluation of water temperature suitability under the PA (panel a) and COS (panel b) for adult immigration of CV spring-run Chinook salmon (Temperature criterion = 68°F 7DADM). Data are modeled monthly water temperatures (not 7DADM), by San Joaquin "60-20-20" year type, under the relevant scenario. Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to any CV spring-run Chinook salmon that may be in the Stanislaus River. There are no month/year type combinations in which monthly water temperatures exceed the temperature criterion. Gray shading indicates month/year type combinations in which the lifestage is not expected to be present in the Stanislaus River.

a) PA scenario

I I I Section 10												
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Goodwin Dam												
Wet	53.0	52.6	50.7	47.9	47.9	49.1	50.0	51.4	51.7	52.4	53.0	53.2
Above Normal	55.4	54.3	51.6	48.5	48.2	49.7	50.6	51.9	52.5	53.8	54.7	55.5
Below Normal	54.4	53.8	51.3	48.7	49.0	50.3	51.7	52.3	53.0	54.1	54.6	54.9
Dry	54.8	54.1	51.4	48.5	48.8	50.7	51.7	52.6	53.7	54.5	54.8	55.1
Critical	57.5	56.4	52.8	49.7	49.8	51.5	52.7	53.9	55.5	56.7	57.8	58.2
	Knights Ferry											
Wet	53.4	52.8	50.6	48.0	48.2	49.3	50.4	52.0	52.6	54.8	55.1	54.7
Above Normal	55.8	54.3	51.3	48.6	48.7	50.6	51.0	52.6	54.7	56.9	57.3	57.4
Below Normal	54.7	53.8	51.1	48.7	49.4	51.3	52.0	52.9	55.1	57.3	57.1	56.8
Dry	55.2	54.1	51.1	48.5	49.3	51.7	52.4	53.7	56.6	57.6	57.3	57.0
Critical	57.9	56.3	52.5	49.6	50.3	52.6	53.6	55.3	58.7	60.3	60.8	60.2
				C	range	Blosson	n					
Wet	54.5	53.6	50.6	48.7	49.3	49.9	51.4	53.3	54.7	59.7	59.7	58.0
Above Normal	56.7	54.8	51.1	49.1	50.0	52.9	51.9	54.1	59.3	63.2	62.6	61.5
Below Normal	55.6	54.4	50.9	49.1	50.5	53.8	52.9	54.3	59.6	63.7	62.4	61.1
Dry	56.2	54.7	50.9	48.9	50.8	54.3	54.1	56.1	62.4	63.9	62.6	61.2
Critical	59.0	56.6	52.1	49.8	51.8	55.3	55.9	58.5	64.9	67.4	66.9	64.5

b) COS scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
Goodwin Dam													
Wet	52.9	52.4	50.6	47.9	47.7	49.2	50.0	51.3	51.6	52.2	52.8	53.0	
Above Normal	55.2	54.5	51.7	48.4	48.0	49.6	50.6	51.9	52.5	53.5	54.5	55.2	
Below Normal	54.9	54.2	51.5	48.7	49.0	50.2	51.4	52.2	53.1	54.2	54.9	55.3	
Dry	55.6	54.8	51.7	48.7	49.0	50.7	51.9	52.7	53.6	54.7	55.3	55.8	
Critical	59.6	57.5	53.1	49.8	49.8	51.4	52.7	54.2	55.9	57.4	58.3	59.7	
	Knights Ferry												
Wet	53.3	52.6	50.5	48.1	48.1	49.4	50.4	51.9	52.7	54.6	54.9	54.5	
Above Normal	55.6	54.5	51.4	48.5	48.5	50.5	51.1	52.7	53.7	56.3	57.0	57.0	
Below Normal	55.1	54.2	51.2	48.8	49.3	51.2	51.9	52.8	54.8	57.3	57.3	57.2	
Dry	55.9	54.8	51.4	48.7	49.4	51.8	52.4	53.4	56.2	57.7	57.7	57.6	
Critical	59.9	57.3	52.7	49.7	50.3	52.5	53.4	55.1	58.3	60.1	60.6	61.1	
				0	range	Blosson	n						
Wet	54.3	53.4	50.5	48.7	49.3	50.2	51.3	53.2	55.2	59.5	59.4	57.8	
Above Normal	56.6	54.9	51.2	49.0	49.9	52.7	52.4	54.6	56.3	61.9	62.2	61.1	
Below Normal	56.0	54.7	51.0	49.2	50.5	53.7	53.0	54.4	58.6	63.5	62.6	61.3	
Dry	56.8	55.3	51.2	49.1	50.7	54.3	53.8	55.2	61.3	63.9	62.9	61.6	
Critical	60.7	57.4	52.4	49.8	51.6	55.2	55.2	57.3	63.3	65.8	65.6	64.7	

Table 2.5.6-17. Evaluation of water temperature suitability under the PA (panel a) and COS (panel b) for spawning, egg incubation, and fry emergence of CV spring-run Chinook salmon (Temperature criterion = 55°F 7DADM). Data are modeled monthly water temperatures (not 7DADM), by San Joaquin "60-20-20" year type, under the relevant scenario. Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to any CV spring-run Chinook salmon that may be in the Stanislaus River. Red shading indicates month/year type combinations in which monthly water temperatures exceed the temperature criterion. Gray shading indicates month/year type combinations in which the lifestage is not expected to be present in the Stanislaus River.

1	TA	
a)	PA	scenario

a) PA scenario	,											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
					Goodw	in Dam						
Wet	53.0	52.6	50.7	47.9	47.9	49.1	50.0	51.4	51.7	52.4	53.0	53.2
Above Normal	55.4	54.3	51.6	48.5	48.2	49.7	50.6	51.9	52.5	53.8	54.7	55.5
Below Normal	54.4	53.8	51.3	48.7	49.0	50.3	51.7	52.3	53.0	54.1	54.6	54.9
Dry	54.8	54.1	51.4	48.5	48.8	50.7	51.7	52.6	53.7	54.5	54.8	55.1
Critical	57.5	56.4	52.8	49.7	49.8	51.5	52.7	53.9	55.5	56.7	57.8	58.2
					Knight	s Ferry						
Wet	53.4	52.8	50.6	48.0	48.2	49.3	50.4	52.0	52.6	54.8	55.1	54.7
Above Normal	55.8	54.3	51.3	48.6	48.7	50.6	51.0	52.6	54.7	56.9	57.3	57.4
Below Normal	54.7	53.8	51.1	48.7	49.4	51.3	52.0	52.9	55.1	57.3	57.1	56.8
Dry	55.2	54.1	51.1	48.5	49.3	51.7	52.4	53.7	56.6	57.6	57.3	57.0
Critical		56.3	52.5	49.6	50.3	52.6	53.6	55.3	58.7	60.3	60.8	60.2
				C	range	Blossor	n					
Wet	54.5	53.6	50.6	48.7	49.3	49.9	51.4	53.3	54.7	59.7	59.7	58.0
Above Normal	56.7	54.8	51.1	49.1	50.0	52.9	51.9	54.1	59.3	63.2	62.6	61.5
Below Normal	55.6	54.4	50.9	49.1	50.5	53.8	52.9	54.3	59.6	63.7	62.4	61.1
Dry	56.2	54.7	50.9	48.9	50.8	54.3	54.1	56.1	62.4	63.9	62.6	61.2
Critical	59.0	56.6	52.1	49.8	51.8	55.3	55.9	58.5	64.9	67.4	66.9	64.5

1	000	
h	(())	scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
	Goodwin Dam												
Wet	52.9	52.4	50.6	47.9	47.7	49.2	50.0	51.3	51.6	52.2	52.8	53.0	
Above Normal	55.2	54.5	51.7	48.4	48.0	49.6	50.6	51.9	52.5	53.5	54.5	55.2	
Below Normal	54.9	54.2	51.5	48.7	49.0	50.2	51.4	52.2	53.1	54.2	54.9	55.3	
Dry	55.6	54.8	51.7	48.7	49.0	50.7	51.9	52.7	53.6	54.7	55.3	55.8	
Critical	59.6	57.5	53.1	49.8	49.8	51.4	52.7	54.2	55.9	57.4	58.3	59.7	
	Knights Ferry												
Wet	53.3	52.6	50.5	48.1	48.1	49.4	50.4	51.9	52.7	54.6	54.9	54.5	
Above Normal	55.6	54.5	51.4	48.5	48.5	50.5	51.1	52.7	53.7	56.3	57.0	57.0	
Below Normal	55.1	54.2	51.2	48.8	49.3	51.2	51.9	52.8	54.8	57.3	57.3	57.2	
Dry	55.9	54.8	51.4	48.7	49.4	51.8	52.4	53.4	56.2	57.7	57.7	57.6	
Critical	59.9	57.3	52.7	49.7	50.3	52.5	53.4	55.1	58.3	60.1	60.6	61.1	
				0	range	Blossor	n	720		,			
Wet	54.3	53.4	50.5	48.7	49.3	50.2	51.3	53.2	55.2	59.5	59.4	57.8	
Above Normal	56.6	54.9	51.2	49.0	49.9	52.7	52.4	54.6	56.3	61.9	62.2	61.1	
Below Normal	56.0	54.7	51.0	49.2	50.5	53.7	53.0	54.4	58.6	63.5	62.6	61.3	
Dry	56.8	55.3	51.2	49.1	50.7	54.3	53.8	55.2	61.3	63.9	62.9	61.6	
Critical	60.7	57.4	52.4	49.8	51.6	55.2	55.2	57.3	63.3	65.8	65.6	64.7	

Under the PA, temperature conditions are:

- Generally suitable for any CV spring-run Chinook salmon juvenile core rearing that may
 be occurring in the Stanislaus River except for June-September of most year types at the
 most downstream location, Orange Blossom Bridge.
- Generally suitable for any adult CV spring-run Chinook salmon immigration that may be
 occurring in the Stanislaus River except (using the lower migration and non-core juvenile
 rearing criterion of 64°F 7DADM) for June-September of critical years at the most
 downstream location, Orange Blossom Bridge.
- Generally not suitable for any CV spring-run Chinook salmon spawning that may be
 occurring in the Stanislaus River (in August to October) except in wet years or
 Novembers at Knights Ferry and Goodwin Dam.
- Generally suitable for any CV spring-run Chinook salmon egg incubation and fry emergence that may be occurring in the Stanislaus River after October.

Any CV spring-run Chinook salmon adults that may be in the Stanislaus River can likely avoid, to some degree, unsuitable water temperatures at Orange Blossom Bridge by moving farther upstream, but that does reflect a reduction of suitable spawning habitat. At a given location, the general seasonal trend in water temperatures means that water temperatures during egg incubation will likely be cooler than during spawning. Any juvenile CV spring-run Chinook salmon that may be in the Stanislaus River can likely avoid, to some degree, unsuitable rearing water temperatures at Orange Blossom Bridge or Knights Ferry by moving farther upstream, but that does reflect a reduction of suitable rearing habitat and may result in increased competition for rearing habitat and food and reductions in growth or survival.

2.5.6.1.6.3 CV Spring-run Chinook Salmon Risk

Based on the effects to any CV spring-run Chinook salmon that may be in the Stanislaus River associated with the PA components described above, fitness consequences to individuals include reduced reproductive success during spawning, reduced survival during embryo incubation, reduced survival and growth during juvenile rearing, and reduced survival and growth during smolt emigration (see Table 2.5.6-12). Additionally, conditions may restrict the window of successful outmigration of individuals and, thus, reduce the diversity of outmigration timing.

2.5.6.2 Alteration of Stanislaus DO Requirement

2.5.6.2.1 Physical Description of the Alteration of Stanislaus DO Requirement

Reclamation is required to meet DO standards on the lower Stanislaus River at Ripon for species protection as required by Reclamation's water rights in conjunction with the local basin plan. Reclamation currently operates to a 7.0 milligrams per liter (mg/L) DO requirement at Ripon year-round. Reclamation monitors and reports daily DO levels at Ripon, as required by the State Water Resources Control Board (D-1422, p. 32). Maintaining DO concentrations above 7.0 mg/L in the Stanislaus River at Ripon requires additional releases from New Melones Dam generally only during low flow, in the summer and early fall. Reclamation proposes to move the compliance location from Ripon to Orange Blossom Bridge, approximately 31 miles upstream, from June 1 to September 30.

2.5.6.2.2 Deconstruct the Action – Proposed Alternation of Stanislaus DO Requirement

Changing the compliance point from Ripon to Orange Blossom Bridge from June 1 to September 30 would decrease DO at Ripon. Cramer Fish Sciences (2006a-d op. cit. ROC on LTO BA) indicated that DO concentrations at the Stanislaus River Weir (approximately 15 miles upstream from Ripon) can be 0.5 to 1 mg/L higher than those measured at Ripon. The DO is approximately 1.0 to 2.0 mg/L higher at Orange Blossom Bridge than at Ripon, so at this rate, if the DO standard of 7.0 mg/L is moved to Orange Blossom Bridge, then the DO at Ripon (31 miles downstream) would be approximately 5.0 to 6.0 mg/L.

2.5.6.2.3 CCV Steelhead and CV Spring-Run Chinook Salmon Exposure, Response, and Risk

2.5.6.2.3.1 CCV Steelhead Exposure

All current stocks of CCV steelhead have a winter run timing, although summer steelhead may have been present prior to the completion of major dams in the Sacramento River system (McEwan and Jackson 1996). The life history strategies of CCV steelhead are extremely variable between individuals, and it is important to take into account that CCV steelhead are iteroparous, and can spawn more than once in their lifetime. Therefore, timing of upstream and downstream migrating adult CCV steelhead (kelts) should be considered. San Joaquin River origin adult CCV steelhead peak in November through January in the Delta (CDFW California Department of Fish and Game 2007), and migrate up the San Joaquin River and its tributaries during a peak timing of November to January. There are limited data on the residence time and run timing of adult CCV steelhead of both Sacramento and San Joaquin River origin in the Delta. Data on the

frequency of occurrence and downstream run timing of CCV steelhead kelts throughout the Central Valley, and the Delta specifically, are very limited.

Based on studies in the Stanislaus River from Oakdale to Goodwin Dam, CCV steelhead are primarily present upstream of Orange Blossom Bridge (Kennedy and Cannon 2002, Kennedy and Cannon 2005, Kennedy 2008) where temperatures and DO levels are suitable.

During these snorkel surveys (in 2005, 2006, and 2007), young trout had the highest densities in September to October and April to July (Kennedy 2008). Therefore, juvenile steelhead may be present in the Stanislaus River when DO would be reduced to less than 7.0 mg/L. However, since juvenile steelhead are most abundant in the upper and middle reaches of the river, they are not expected to be present below Orange Blossom Bridge. Adult rainbow trout, including some that appeared to be steelhead, were observed sporadically in the river during summer surveys. All observations of adults were above Orange Blossom Bridge. Similar to juvenile, adult steelhead are not expected to be present below Orange Blossom Bridge during the warm summer months when DO would be less than 7.0 mg/L.

2.5.6.2.3.2 CV Spring-Run Chinook Salmon Exposure

Although there is limited data on temporal occurrence of spring-run Chinook salmon in the Stanislaus River, observations of spring-running fish, adults holding over the summer, and early fry have been reported.

Based on snorkel surveys (Kennedy and Cannon 2002, Kennedy and Cannon 2005, Kennedy 2008), Chinook salmon fry (which are likely primarily fall-run, but may be roughly representative of the distribution of occasional spring-run Chinook salmon fry that may be in the Stanislaus River) had a peak presence from January to March in the middle and lower reaches of the Stanislaus River study area, and juveniles were abundant in late winter and early summer throughout most of the river from Goodwin Dam downstream to Oakdale. Their distribution shifted downstream through the spring and their numbers declined sharply from mid-April to mid-June coincident with the Vernalis Adaptive Management Program (VAMP) experimental storage releases from New Melones Reservoir. The VAMP flows likely encouraged young salmon to leave the river and migrate to the Delta. All observations of adults were above Orange Blossom Bridge. Chinook salmon were most abundant near Goodwin Dam from July to October, where water temperatures remained around 12°C (54°F).

Chinook salmon present in the Stanislaus River are mostly fall-run Chinook salmon, however, CV spring-run Chinook salmon are occasionally present. Since adults hold upstream over summer, they will not be affected by the change in DO requirement. Fry emerging in January to March are assumed to come from upstream spawning areas near Goodwin Dam. Any juvenile CV spring-run Chinook salmon that may be in the Stanislaus River may be exposed to the change in DO during early summer months as they are rearing or outmigrating.

2.5.6.2.3.3 CCV Steelhead and CV Spring-run Responses

Since effects to CCV steelhead and any CV spring-run Chinook salmon that may be in the Stanislaus River are similar, discussion of responses are combined below.

Adequate water quality, including temperature, salinity, DO concentrations, and other chemical characteristics necessary for normal behavior, growth, and viability of all salmonid life stages are

required for the proper functioning of salmonid species. Reduced levels of DO can impact growth and development of different steelhead and spring-run life stages. Such impacts can affect fitness and survival by altering embryo incubation periods, decreasing the size of fry, increasing the likelihood of predation, and decreasing feeding activity. Extremely low DO concentrations can be lethal to salmonids (California Regional Water Quality Control Board 2005). The upstream migration of adult salmonids requires swimming long distances and uses high expenditures of energy, which requires sufficient levels of DO. According to Hallock et al. (1970), migrating adult Chinook salmon in the San Joaquin River exhibited an avoidance response when DO was below 4.2 mg/L, and most Chinook salmon waited to migrate until DO levels were at least 5 mg/L. Salmonids may be able to survive when DO concentrations are low (<5 mg/L), but growth, food conversion efficiency, and swimming performance will be negatively affected (Bjornn and Reiser 1991). California Regional Water Quality Control Board (2005)referred to numerous studies and reported no impairment to rearing salmonids if DO concentrations averaged 9 mg/L, while DO levels of 6.5 mg/L result in symptoms of oxygen distress. Field and laboratory studies have found that juvenile salmonids consistently avoid DO concentrations of 5 mg/L and lower, and there is some indication that avoidance is triggered at concentrations as high as 6 mg/L.

Changing the DO requirement location on the Stanislaus River from Ripon upstream to Orange Blossom Bridge would likely decrease DO downstream of the Orange Blossom Bridge by approximately 1 to 2 mg/L. This may result in juveniles avoiding the area during rearing or downstream migration. Adults would likely not be affected since they are not likely to avoid the area unless DO is below 4.2 mg/L, and adults are known to be present above Orange Blossom Bridge, where DO would be at least 7.0 mg/L.

2.5.6.2.3.4 Risk to CCV Steelhead

Adult CCV steelhead may be present in the Stanislaus River during the summer months when DO may be lower at Ripon as a result of the PA, however, adult CCV steelhead have only been observed holding upstream of Orange Blossom Bridge, 31 miles upstream of the Ripon compliance point where DO is greater than 7.0 mg/L. Therefore, adult CCV steelhead are not expected to be exposed to the effects of altering the DO requirements at Ripon.

Juvenile CCV steelhead may also be present in the Stanislaus River during the summer months while rearing or migrating downstream. Juvenile CCV steelhead observations during snorkel surveys were primarily upstream of Orange Blossom Bridge. Though a few juvenile CCV steelhead may be migrating past Ripon during the time the DO requirement is relaxed, the time of exposure to potentially lower levels (5 to 6 mg/L) of DO is expected to be short term. Juvenile salmonids are known to avoid migrating when DO is 5.0 mg/L or lower, and there may be oxygen distress from DO of 6.5 mg/L or less (California Regional Water Quality Control Board 2005). Since most juvenile CCV steelhead will be upstream during summer months when DO is low, they would not be negatively affected by the PA component. However, the small number of juveniles migrating past Ripon during the summer months may avoid areas where DO is less than 5.0 mg/L, which would delay their outmigration. Fish that pass through the area rather than avoid it would be exposed to short term oxygen distress. These responses would result in reduced fitness levels.

2.5.6.2.3.5 Risk to CV Spring-Run Chinook Salmon

Adult Chinook salmon may be present in the Stanislaus River from March through September according to historical temporal occurrence (Table 2.5.7-12). All adult Chinook salmon snorkel survey observations were upstream of Orange Blossom Bridge. Some of these observed adults may be CV spring-run Chinook salmon. However, since any adult CV spring-run Chinook salmon that may be in the Stanislaus River are not expected to be present near Ripon during the summer months when DO would be lower than 7.0 mg/L (when flows are low and water temperatures are high), they would not be affected by the low DO as a result of the requirement at Ripon.

Any juvenile CV spring-run Chinook salmon that may be present in the Stanislaus River could be present in the river year round while rearing, however they are likely to be migrating downstream in winter and spring, and into early summer months. Based on observations and seasonal timing, any juvenile CV spring-run Chinook salmon that may be in the Stanislaus River may be negatively affected by low DO as a result of the requirement at Ripon since a small proportion of late migrating juveniles are expected to be passing Ripon during times when DO would be as low as 5.0 mg/L as a result of the PA. When DO is less than 5.0 mg/L, juvenile salmonids are known to avoid the area, which would delay their outmigration and would affect fitness levels below Ripon.

2.5.6.3 Conservation Measures

2.5.6.3.1 Spawning and Rearing Habitat Restoration

Reclamation proposes the following commitments to habitat restoration on the Stanislaus River:

- **Spawning Habitat:** Under the CVPIA (b)(13) program, Reclamation's annual goal of gravel placement is approximately 4,500 tons in the Stanislaus River.
- Rearing Habitat: Reclamation proposes to construct an additional 50 acres of rearing habitat adjacent to the Stanislaus River by 2030.

A summary of restoration projects completed on the Stanislaus River since 2009 is provided in Table 2.5.6-18.

Table 2.5.6-18. Summary of completed (since 2009) and potential habitat restoration projects on the Stanislaus River. Information from Table 2-3 of the WY 2018 Stanislaus Operations Group Annual Report (National Marine Fisheries Service 2018h).

 a) COMPLETED gravel augmentation projects (for spawning habitat at all locations; some gravel placed at the cable crossing in Goodwin Canyon intended for mobilization and downstream placement by river flows)

COMPLETED Gravel Project	Project extent
Goodwin Canyon at cable crossing - 2011	2,941 cubic yards
Goodwin Canyon at float tube pool - 2012	1,765 cubic yards
Goodwin Canyon at cable crossing - 2015	4,706 cubic yards
Main channel and floodplain bench at Honolulu Bar - 2012	8,000 cubic yards total used for spawning riffles in main channel and 0.7 acre floodplain bench
Buttonbush - 2017	2,838 cubic yards
Rodden Road - 2018	1,250 cubic yards

b) COMPLETED floodplain and side-channel restoration projects (for improved rearing habitat, improved migratory habitat, improved connectivity to avoid stranding)

COMPLETED Restoration Project	Project extent
Lancaster Road side-channel - 2011	640 linear feet of side-channel and 2 acres of floodplain habitat
Side-channel at Honolulu Bar - 2012	Improvement of existing side-channel to reduce stranding risk
Floodplain at Honolulu Bar - 2012	2.4 acres
Buttonbush - 2017	4.4 acres of side-channel and floodplain habitat and 2,400 linear feet of side-channel habitat.
Rodden Road - 2018	4.9 acres of habitat

c) Potential gravel and habitat restoration projects.

POTENTIAL Project	Project extent
Two Mile Bar	Anticipated gravel: 6,000 cubic yards.
	Anticipated habitat: TBD
Kerr Park Restoration	Anticipated gravel and habitat: TBD
Migratory Corridor Rehabilitation	Anticipated gravel and habitat: TBD
Goodwin Canyon	Anticipated gravel: TBD

In summary, in the 10-year period from 2009 through 2018, an average annual placement of 3,225 tons²³ was achieved, and a total of 13.8 acres and 3,040 linear feet of floodplain and side channel habitat was restored. Reclamation has been working to remove impediments to gravel augmentation in Goodwin Canyon (the easiest and least expensive option), however, restoration at the scale proposed will require partnerships with private landowners as well as funding, contracting, and permitting processes. Because it is not clear what assumptions Reclamation has made to conclude that restoration of 50 acres (over 3 times the restored acreage achieved in the past 10 years) is achievable by 2030, NMFS considers the full 50-acre target at a framework-level, with site-specific coverage within the limits identified below.

In this consultation, NMFS assumes that:

- Reclamation can achieve, on average, 4,500 tons/year of gravel augmentation. If annual
 targets are not achieved in some years, NMFS assumes that Reclamation will make
 additional catch-up contributions in other years to meet the 4,500 tons/year average by
 2030. Exemptions from take prohibitions are included under the Central Valley
 Restoration Programmatic Opinion, for any project that meets the guidelines; projects
 outside those guidelines need separate ESA consultation.
- Reclamation will restore up to 50 acres of rearing habitat by 2030. NMFS considers the
 effects of the full 50-acre target at a framework-level. Exemptions from take prohibitions
 are included under the Central Valley Restoration Programmatic Opinion, for any project
 that meets the guidelines; projects outside those guidelines need separate ESA
 consultation.

2.5.6.3.1.1 CCV Steelhead Exposure, Response, and Risk

Habitat restoration activities would directly benefit CCV steelhead by increasing the quantity and quality of spawning habitat, creating side channel and floodplain rearing habitat, and increasing the quality and quantity of off-channel rearing habitat in the Stanislaus River. Habitat restoration activities within the Stanislaus River would yield benefits to CCV steelhead adults and juveniles by increasing existing riparian vegetation, providing instream and overhanging object cover, new shaded riverine habitat, and additional area for food production, and would also increase the aquatic habitat complexity and diversity within the Stanislaus River and provide additional predator escape cover. Additionally, the created side channel and floodplain habitat would provide additional refuge for outmigrating juvenile CCV steelhead. These habitat benefits are expected to result in increased growth, fitness, and survival.

Construction activities associated with spawning and rearing habitat restoration projects under this PA component are not expected to result in any direct effects to CCV steelhead adults, eggs or emerging fry, based on timing of in-water construction (July 15 through October 15²⁴), typical seasonal occurrence of these life stages in the Stanislaus River (December through June), and implementation of general avoidance and minimization measures. Construction activities associated with spawning and rearing habitat construction could result in minor, short-term, impacts to juvenile CCV steelhead (disruption to behavior, temporary displacement, increased

²⁴ While not specified in the PA, July 15 through October 15 is the window evaluated in the effects analysis of the ROC on LTO BA.

²³ The total gravel volume from the projects listed in Table 2.5.6-18 is 21,500 cubic yards. Assuming a conversion of 1.5 tons/cy, the total is 32,250 tons over the 10-year period which represents an annual placement rate of 3,225 tons per year.

turbidity) for restoration projects upstream of Orange Blossom Bridge, since juvenile CCV steelhead are present year-round in that area. Although not specified in the ROC on LTO BA, we assume standard avoidance and minimization measures typical for restoration work would be implemented, and therefore expect impacts limited to short-term behavioral changes not affecting fitness or survival.

Habitat restoration would result in an overall benefit to the CCV steelhead.

2.5.6.3.1.2 CV Spring-run Chinook Salmon Exposure, Response, and Risk

Habitat restoration activities would directly benefit any CV spring-run Chinook salmon that may be in the Stanislaus River, increasing the quantity and quality of spawning habitat for adults and eggs through fry emergence, and the quantity and quality of rearing and migratory habitat in the Stanislaus River for rearing and outmigrating juveniles (see details in the discussion for CCV steelhead in Section 2.5.6.3.1.1).

Any CV spring-run Chinook salmon adults and eggs that may be in the Stanislaus River would have the potential to be affected by construction activities associated with the restoration activities in the Stanislaus River given the proposed July 15 through October 15 in-water work window. Any CV spring-run Chinook salmon adults and eggs that may be in the Stanislaus River are most likely to be present during the work window in the coolest reaches of the Stanislaus River in or near Goodwin Canyon; projects located in warmer reaches may not overlap with any CV spring-run Chinook salmon adults that are present or spawning locations and implementation of avoidance and minimization measures will help to limit impacts. Construction activities associated with the restoration activities in the Stanislaus River are unlikely to affect any CV spring-run Chinook salmon fry that may be in the Stanislaus River (since that life stage is not expected during the in-water work window from July 15 through October 15) but restoration projects upstream of Orange Blossom Bridge could affect juveniles oversummering to outmigrate as yearlings, resulting in minor, short-term, impacts (disruption to behavior, temporary displacement, increased turbidity). Effects can be minimized based on standard avoidance and minimization measures typical for restoration work.

Habitat restoration would have an overall benefit to any CV spring-run Chinook salmon that may be in the Stanislaus River, resulting in increased growth, fitness, and survival.

2.5.6.3.2 Temperature Management Study

Reclamation proposes that it "will study approaches to improving temperature for listed species on the lower Stanislaus River, to include evaluating the utility of conducting temperature measurements/profiles in New Melones Reservoir." NMFS supports this commitment and urges Reclamation to consider developing a simple temperature forecasting tool that could be used by the Stanislaus Watershed Team to screen alternate flow schedules when shaping seasonal flows.

2.5.6.3.2.1 CCV Steelhead Exposure, Response, and Risk

The study itself will not affect CCV steelhead in the Stanislaus River. The study may improve management of temperatures and flows in the future, and help to inform decisions of the Stanislaus Watershed Team.

2.5.6.3.2.2 CV Spring-run Chinook Salmon Exposure, Response, and Risk

The study itself will not affect any CV spring-run Chinook salmon that may be in the Stanislaus River. The study may improve management of temperatures and flows in the future, and help to inform decisions of the Stanislaus Watershed Team.

2.5.7 San Joaquin River (East Side Division)

The analysis in this section, and references to "San Joaquin River", are limited in geographic extent to the San Joaquin River from the confluence with the Stanislaus River downstream past Vernalis to approximately Mossdale (as described in the Action Area section). While this reach of the San Joaquin River is in the statutory Delta, there are several reasons to consider it separately from the Delta effects section. First, conditions are primarily driven by upstream operations on CVP and non-CVP watersheds (including operations on the Stanislaus River) rather than Delta operations. Second, this reach of the San Joaquin River is primarily riverine, while further in the Delta the San Joaquin River is primarily tidal. The PA components being consulted on (Table 2.5.7-1) do not include any operational components that originate within this reach; conditions in the reach under the PA scenario ("PA conditions") are primarily affected by (1) San Joaquin River flow from upstream of the confluence with the Stanislaus River (the boundary of the action area), (2) flow entering the San Joaquin River from the Stanislaus River as a results of East Side Division operations (described in detail in Section 2.5.6), including assumptions made in the ROC on LTO BA about the flow requirement at Vernalis (a compliance location within this reach) per the Bay Delta Water Quality Control Plan that can affect East Side Division operations, and (3) accretions and depletions within the reach. NMFS evaluates the effects of East Side Division operations in this reach of the San Joaquin River, in combination with the baseline boundary flows, accretions and depletions, under a project component named "PA conditions." The PA components being consulted on do include a conservation measure for Lower San Joaquin River Rearing Habitat.

The analysis of effects to species in the San Joaquin River focuses on effects to particular life history stages of CCV steelhead, sDPS green sturgeon, and (for informational purposes) any CV spring-run Chinook salmon that may be present in this reach of the San Joaquin River. Note that in the CV spring-run Chinook salmon Integration and Synthesis Section (Section 2.8.3), NMFS discusses the San Joaquin experimental population and associated 4(d) rule with respect to findings under this Opinion.

A summary of which stressors from the "Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead" (National Marine Fisheries Service 2014b) will be analyzed under each PA component within this effects analysis for the San Joaquin River is provided in Figure 2.5.6-1.

Table 2.5.7-1. Summary of which stressors from the "Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead" (NMFS 2014) will be analyzed under each PA component within this effects analysis for the San Joaquin River. An "X" indicates the stressor will be analyzed for at least one life-stage and species and a "-" indicates that the stressor is not applicable for a particular PA component.

Project Component	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
2.5.8.1 PA Conditions	-	-	X	-	x	Х	X	X	-	¥	X	Х	-	X	ı.
2.5.8.2.1 Conservation Measures – Lower San Joaquin River Habitat	**	-	-	-	-	X	x	X	-		X	港里	.=	х	5

A summary of which stressors from the "Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon" (NMFS 2018) will be analyzed under each PA component within this effects analysis for the San Joaquin River is provided in Table 2.5.7-2.

Table 2.5.7-2. Summary of which stressors from the "Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon" (NMFS 2018) will be analyzed under each PA component within this effects analysis for the San Joaquin River. An "X" indicates the stressor will be analyzed for at least one life-stage and species and a "-" indicates that the stressor is not applicable for a particular PA component.

Project	Passage Impediments/Barriers to Migration	Altered Flow	Altered Water Temperature	Altered Sediments	Altered Turbidity	Take (Entrainment, Poaching & Bycatch)	Contaminants	Altered Prey Base	Competition for Habitat	Loss of Wetland Function	Predation	Water Depth Modification	Disease	Climate Change
Component	Pa: to I	Alt	Alt	Alt	Alt	Tal Bye	Co	Alt	CO	Los	Pre	Wa	Dis	Cli
2.5.8.1 PA Conditions	-	х	х	х	х	1+1	-	х	х	х	х	х) <u>*</u>)	s -

Project Component	Passage Impediments/Barriers to Migration	Altered Flow	Altered Water Temperature	Altered Sediments	Altered Turbidity	Take (Entrainment, Poaching & Bycatch)	Contaminants	Altered Prey Base	Competition for Habitat	Loss of Wetland Function	Predation	Water Depth Modification	Disease	Climate Change
2.5.8.2.1 Conservation Measures – Lower San Joaquin River Habitat	ā	x	x	х	х	101	-	x	x	х	x	х	-	-

2.5.7.1 PA Conditions

Effects of East Side Division operations in this reach of the San Joaquin River, in combination with the baseline boundary flows, accretions and depletions, are considered "PA conditions." See Section 2.5.6 for a detailed discussion of how East Side Division operations on the Stanislaus River affect the flows entering the San Joaquin River. Table 2.5.7-3 shows average monthly modeled flows at Vernalis in the PA and COS scenarios.

Table 2.5.7-3. Exceedance table of average modeled monthly flow in the San Joaquin River at Vernalis for the PA scenario and COS scenario. Interpretation of year type differences from these tables is complicated by the fact that both PA and COS flows are summarized by the 60-20-20 year type, even though COS flows on the Stanislaus River are modeled based on the NMI year type. (Source: Table 39b-3 from Appendix D, Attachment 3-2, of the ROC on LTO BA.)

Table 39b-3. San Joaquin River at Vernalis (60-20-20), Monthly Flow

						Monthly Fl	ow (CFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance							77.1		1,000	21217		
10%	3,499	2,953	4,804	11,236	14,693	15,582	14,771	14,178	9,432	5,890	2,796	3,060
20%	3,162	2,777	2,857	4,812	10,133	10,196	10,640	8,319	4,695	2,634	2,595	2,655
30%	2,980	2,527	2,401	3,611	6,119	8,499	8,616	5,538	3,364	1,990	1,909	2,491
40%	2,796	2,395	2,216	2,629	4,232	5,570	7,564	4,615	2,947	1,741	1,672	2,125
50%	2,602	2,219	2,101	2,402	3,420	3,847	6,019	3,929	2,244	1,493	1,492	1,932
60%	2,401	2,169	2,046	2,293	2,684	3,459	4,835	3,064	1,864	1,370	1,408	1,837
70%	2,247	2,059	1,979	2,114	2,305	2,906	3,778	2,705	1,449	1,163	1,310	1,741
80%	1,995	1,951	1,829	1,883	2,151	2,371	2,792	2,167	1,298	1,099	1,207	1,613
90%	1,849	1,763	1,669	1,699	1,947	2,205	1,888	1,680	1,091	891	1,068	1,477
Long Term Full Simulation Period ^a	2,672	2,613	3,393	5,079	6,664	7,282	7,522	6,066	4,211	2,630	1,850	2,225
Water Year Types b,c												
Wet (23%)	3,611	4,025	6,134	11,463	15,794	16,880	15,399	14,703	11,398	6,693	3,136	3,417
Above Normal (24%)	2,947	2,582	2,953	4,898	6,903	7,536	8,537	5,295	3,282	1,,996	1,979	2,347
Below Normal (10%)	2,518	2,133	2,067	3,520	3,651	4,149	6,338	4,142	2,077	1,466	1,448	1,838
Dry (16%)	2,289	2,153	3,123	2,402	2,549	3,241	3,998	2,808	1,685	1,260	1,351	1,778
Critical (27%)	1,864	1,849	2,077	1,878	2,091	2,288	2,310	1,932	1,119	932	1.064	1,489

Proposed Action 01151						Monthly Fl	ow (CFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	3,500	2,975	4,804	12,398	17,192	15,482	15,015	15,004	9,433	5,780	2,744	3,060
20%	3,148	2,778	2,904	4,838	10,122	10,324	10,641	8,327	4,781	2,503	2,602	2,635
30%	2,996	2,483	2,321	3,613	6,806	8,470	8,960	5,767	2,704	1,957	1,894	2,486
40%	2,835	2,395	2,204	2,681	4,232	5,306	7,921	4,655	2,370	1,730	1,679	2,128
50%	2,628	2,219	2,101	2,371	3,071	3,847	6,437	4,131	2,069	1,507	1,497	1,933
60%	2,402	2,170	2,046	2,290	2,614	3,440	4,786	2,910	1,757	1,362	1,407	1,830
70%	2,137	2,060	1,979	2,084	2,305	2,906	3,212	2,305	1,351	1,153	1,319	1,743
80%	1,978	1,951	1,829	1,883	2,128	2,372	2,500	1,866	1,217	994	1,136	1,575
90%	1,807	1,763	1,669	1,699	1,891	2,205	1,765	1,473	978	874	1,029	1,452
Long Term Full Simulation Period ^a	2,669	2,607	3,368	5,109	6,792	7,290	7,513	5,982	4,102	2,619	1,831	2,214
Water Year Types b,c												
Wet (23%)	3,607	4,001	6,006	11,466	16,343	17,052	15,339	14,678	11,759	6,815	3,125	3,417
Above Normal (24%)	2,994	2,579	2,964	4,928	6,922	7,468	8,887	5,409	2,691	1,915	1,976	2,340
Below Normal (10%)	2,542	2,133	2,067	3,784	3,834	4,032	6,497	4,189	1,974	1,473	1,454	1,836
Dry (16%)	2,239	2,153	3,132	2,393	2,464	3,241	3,795	2,537	1,570	1,245	1,349	1,776
Critical (27%)	1,829	1,849	2,077	1,871	2,058	2,274	2,071	1,680	1,040	864	1,003	1,457

						Monthly Flo	ow (CFS)					
Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Probability of Exceedance												
10%	1	22	0	1,162	2,499	-100	245	826	1	-111	-52	(
20%	-14	0	47	26	-11	128	1	7	87	-131	7	-20
30%	16	45	-79	3	687	-29	344	229	-660	-33	-15	-
40%	39	0	-11	52	0	-264	357	39	-577	-11	7	2
50%	26	0	0	-30	-349	0	419	202	-175	14	5	1
60%	1	0	0	-3	-70	-19	-48	-154	-107	-9	-1	-8
70%	-111	1	0	-30	0	0	-566	-400	-98	-10	9	2
80%	-17	-1	0	-1	-23	0	-292	-301	-81	-105	-71	-38
90%	-42	0	0	0	-56	0	-123	-208	-113	-17	-39	-25
Long Term Full Simulation Period ^a	-4	-6	-26	31	127	8	-10	-84	-110	-11	-20	-11
Water Year Types ^{b,o}												
Wet (23%)	-4	-24	-128	3	550	171	-61	-25	362	122	-11	(
Above Normal (24%)	47	-3	11	31	19	-68	349	114	-591	-80	4	-6
Below Normal (10%)	23	0	0	264	183	-117	159	47	-103	7	6	10
Dry (16%)	-50	0	9	-9	-85	1	-203	-271	-114	-15	-1	-4
Critical (27%)	-36	0	0	-7	-33	-15	-239	-253	-80	-68	-61	-32

a Based on the 82-year simulation period

b As defined by the San Joaquin Valley 60-20-20 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).

C These results are displayed with calendar year - year type sorting.

d All scenarios are simulated at ELT (Early Long-Term) Q5 with 2025 climate change and 15 cm sea level rise.

e These are draft results meant for qualitative analysis and are subject to revision.

The largest reductions in flow in the PA relative to the COS occur in April to June, likely related to some combination of changes in the assumed Vernalis requirements and the SRP. In a Critical year, for example, the average 239 cfs decrease in April flows in the PA represents a 10 percent decrease from the average April COS flows of 2,310 cfs; the average 253 cfs decrease in May flows in the PA represents a 13 percent decrease from the average May COS flows of 1,932 cfs; the average 80 cfs decrease in June flows in the PA represents a 7 percent decrease from the average June COS flows of 1,119 cfs.

Higher flows tend to result in cooler water temperatures at Vernalis. Water temperatures are also highly affected by air temperature (Figure 2.5.7-1). Higher flows and cooler temperatures typically extend into summer in wetter years.

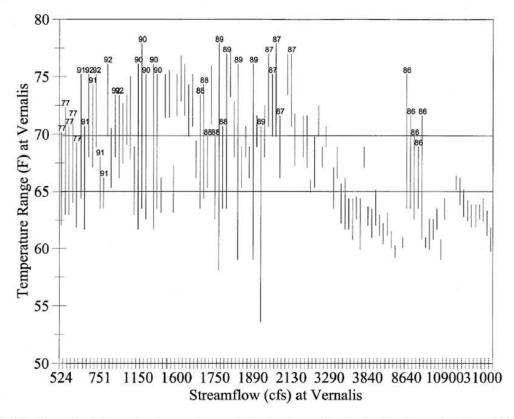


Figure 2.5.7-1. Range in daily water temperature relative to streamflow in the San Joaquin River at Vernalis from the period of May 13-17 in 1962, 1963, 1970, and 1973 to 1994. [Source: Figure 11 from Mesick (2001)]

Monthly average water temperatures at Vernalis by month and San Joaquin ("60-20-20") year type are provided in Table 2.5.7-4 to show the range of temperatures expected under the PA and COS.

Table 2.5.7-4. Monthly average water temperatures at Vernalis by month and San Joaquin ("60-20-20") year type for PA and COS scenarios.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
				Vernalis	s water te	mperature	s under I	PA				
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
Dry & Critical	64.7	56.6	49.1	48.5	54.5	60.3	64.9	69.4	75.4	78.7	77.3	73.6
~~~		X		Vernalis	water ter	perature	under C	os			7	
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6
Dry & Critical	64.9	56.7	49.1	48.5	54.5	60.3	64.1	68.1	74.9	78.3	76.9	73.4

# 2.5.7.1.1 CCV Steelhead Exposure, Response, and Risk

# 2.5.7.1.1.1 CCV Steelhead Exposure

Life history timing of CCV steelhead adults and juveniles in the mainstem San Joaquin River is described in Table 2.5.7-5. Additionally, CCV steelhead may exit the Stanislaus River during winter storm flows [similar to juvenile Chinook salmon as described in Sturrock et al. (2015)] and rear in the mainstem San Joaquin River from roughly December to May. Some CCV steelhead in the mainstem San Joaquin River may residualize and not exhibit the sea-going life history, but water temperatures in the mainstem San Joaquin River are unsuitable for juvenile CCV steelhead in the summer and fall, so juveniles would not be expected to be present in those seasons.

Table 2.5.7-5. Temporal occurrence of (a) adult and (b) juvenile California Central Valley steelhead.

Relative Abundance		H	gh			Med	lium			L	ow	
(a) Adult migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River near Fremont Weir ¹												
Sacramento R. at Red Bluff ²												
Delta ^{3,4}												
San Joaquin River ⁴												
(b) Juvenile migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River near Fremont Weir ^{1,2}												
Sacramento River at Knights Landing ^{2,5}												
Chipps Island (clipped) ⁶												
Chipps Island (unclipped) 6												

Relative Abundance		Hi	gh		M	edi	um			L	ow		
San Joaquin R. at Mossdale ⁶						Ĭ	j						
Stanislaus R at Caswell ⁷													П

Sources: ¹(Hallock et al. 1957); ²(McEwan 2001); ³ (Hallock et al. 1961, Moyle 2002); ⁴(California Department of Fish and Game 2007); ⁵NMFS analysis of 1998-2011 CDFW data; ⁶NMFS analysis of 1998-2018 USFWS data; Ōakdale RST data (collected by Fishbio) summarized by John Hannon (Reclamation)

# 2.5.7.1.1.2 CCV Steelhead Response

Expected effects from the PA Conditions in the lower San Joaquin River will expose CCV steelhead to limited rearing habitats and potential migrational delays, leading to increased vulnerability to factors including poor water quality, which reduce survival, including predation. Life stage-specific responses to specific stressors related to the PA Conditions are summarized in Table 2.5.7-6. This effects analysis identifies and describes the most important project-related stressors to these species. All project-related stressors acting on San Joaquin River CCV steelhead are identified in Table 2.5.7-6.

Table 2.5.7-6. The temporal and spatial co-occurrence of CCV steelhead life stages and the stressors associated with PA Conditions in the San Joaquin River between the confluence of the Stanislaus River and Mossdale.

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction			
Juvenile rearing	Dec-May	Lack of overbank flow to inundate rearing habitat	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival			
Juvenile rearing	Dec-May	Reduction in rearing habitat complexity due to reduction in channel forming flows	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival			
Juvenile rearing	Dec-May	Springtime water temperatures warmer than life history stage requirements, primarily March- May	Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	Reduced growth rates; Reduced survival			

Life Stage/ Location	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Juvenile out- migration	Feb-Jun	Water temperatures warmer than life history stage requirements, primarily in May and June	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress;	Reduced survival; Reduced diversity in outmigration timing
Juvenile out- migration	Feb-Jun	Suboptimal flow	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	Reduced survival; Reduced diversity in outmigration timing

Many of the flow-related stressors affecting CCV steelhead in this reach of the San Joaquin River identified in Table 2.5.7-6 above are similar to those discussed for CCV steelhead in the Stanislaus River in Section 2.5.6.1.5.1. Water temperatures, however, are separately evaluated below since water temperatures are higher on the San Joaquin River than the Stanislaus River.

Suitable temperatures for each CCV steelhead life stage (with life-stage timing noted) are summarized in Table 2.5.7-7 and the evaluation of monthly average water temperatures at Vernalis under the PA using these criteria is summarized in. Because the modeled monthly temperatures are lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to CCV steelhead on the San Joaquin River.

Table 2.5.7-7. Salmonid temperature requirements by life stage from Table 3 and Table 4 of the U.S. EPA's Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003), along with CCV steelhead life stage timing in the San Joaquin River. 7DADM is 7-day average of the daily maximum temperature. Because the modeled monthly temperatures are lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to CCV steelhead on the San Joaquin River.

Life Stage & Timing	<b>Temperature Criterion</b>
Salmon/trout juvenile rearing	61°F 7DADM
(December - May)	
Salmon/trout migration plus non-core juvenile rearing	64°F 7DADM
(Combined: year-round)	
Adult migration: July-March	
Juvenile migration: February-June	
Non-core juvenile rearing: December -May	
Salmon/trout migration	68°F 7DADM
(Combined: year-round)	
Adult migration: year-round	
Juvenile migration: February-June	

Table 2.5.7-8. Evaluation of water temperature suitability under the PA (panel a) and COS (panel b) for CCV steelhead for various lifestages. Data are modeled monthly water temperatures (not 7DADM), by San Joaquin "60-20-20" year type, under the relevant scenario. Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to CCV steelhead on the Stanislaus River. Red shading indicates month/year type combinations in which monthly water temperatures exceed the temperature criterion. Gray shading indicates month/year type combinations in which the lifestage is not expected to be present in the San Joaquin River.

# a) PA scenario

1 /1 Section in	,											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
			Juve	nile reari	ng (61°F	7DADM)	- Decemb	ber - May				
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
		Mig	ration plu	s non-cor	e juvenile	rearing (6	4°F 7DA	DM) - Ye	ar-round			
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.3	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
		Mig	ration plu	s non-cor	e juvenile	rearing (6	8°F 7DA	DM) – Ye	ar-round			
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7

# b) COS scenario

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
- '			Juve	nile reari	ng (61°F	DADM)	- Decem	ber - May				-
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6
		Mig	ration plu	s non-cor	e juvenile	rearing (6	4°F 7DA	DM) Ye	ar-round			
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.5
		Mig	ration plu	s non-cor	e juvenile	rearing (6	8°F 7DA	DM) Ye	ar-round			
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6

Water temperatures at Vernalis are mostly unsuitable for rearing in late spring, especially in drier years. Water temperatures at Vernalis are likely to be stressful to outmigrating CCV steelhead, or even serve as a barrier to migration, in May through September. According to Deas (2004), in April, May and particularly June, San Joaquin River water temperatures can reach stressful levels and may be limiting to young salmonids.

#### 2.5.7.1.1.3 CCV Steelhead Risk

Based on the effects to CCV steelhead associated with the PA Conditions described above, fitness consequences to individuals include reduced survival and growth during juvenile rearing, and reduced survival and growth during juvenile outmigration in the lower San Joaquin River (see Table 2.5.7-6). Additionally, conditions may restrict the window of successful outmigration of individuals and, thus, reduce the diversity of outmigration timing through the lower San Joaquin River for all the San Joaquin River steelhead populations.

# 2.5.7.1.2 CV Spring-run Chinook Salmon Exposure, Response, and Risk

# 2.5.7.1.2.1 CV Spring-run Chinook Salmon Exposure

Any adult CV spring-run Chinook salmon that may be in this reach of the San Joaquin River may be affected by warm water temperatures, primarily in June to September, that have not reached tributaries before temperatures rise at lower river reaches. This will result in thermal stress and mortality of individuals. Warm water temperatures in the springtime may also affect any juvenile CV spring-run Chinook salmon that may be in this reach of the San Joaquin River by causing metabolic stress, starvation, and loss to predation, resulting in reduced growth and survival. Juveniles may also be affected by decreased flow since this would reduce inundated rearing habitat, channel complexity, and may increase predation as they are less able to avoid them. Life history timing of any CV spring-run Chinook salmon adults and juveniles that may be in the mainstem San Joaquin River is described in Table 2.5.7-9, and stressors and responses are described in Table 2.5.7-10.

Relative Abundance High Medium Low (a) Adult Migration Jan Feb Mar May Jun Jul Nov Location Apr Aug Sep Oct Dec Delta^a San Joaquin Basin Sac. River Basinb,c Sac. River Mainstemc,d b) Adult Holdingb,c c) Adult Spawningb,c,d (b) Juvenile Migration Location Jan Feb Mar Apr May Jun Jul Oct Nov Dec Aug Sep Sac. River at RBDDd Sac. River at KLi

Table 2.5.7-9. Temporal occurrence of adult (a) and juvenile (b) CV spring-run Chinook salmon in the Central Valley, including the San Joaquin basin.

Sources: a(CDFW 1998); b(Yoshiyama et al. 2001); c(Moyle 2002); d(Myers et al. 1998); c(Lindley et al. 2004). (CDFG 1998); g(McReynolds et al. 2007); b(Ward et al. 2003); d(CDFW 1998-2019); d(USFWS 2000-2019)

Note: Yearling CV spring-run Chinook salmon rear in their natal streams through the first summer. Downstream emigration generally occurs the following fall and winter. Most young-of-year CV spring-run Chinook salmon emigrate during the first spring after they hatch.

## 2.5.7.1.2.2 CV Spring-run Chinook Salmon Response

San Joaquin basin

Delta

Expected effects from the PA Conditions will expose any CV spring-run Chinook salmon that may be in this reach of the San Joaquin River to limited rearing habitats and potential migrational delays, leading to increased vulnerability to factors such as poor water quality, which reduce survival, including predation. Life stage-specific responses to specific stressors related to the PA Conditions are summarized in

Table 2.5.7-10. This effects analysis identifies and describes the most important project-related stressors to these species. All project stressors acting on any CV spring-run Chinook salmon that may be in this reach of the San Joaquin River are identified in Table 2.5.7-6.

Table 2.5.7-10. The temporal and spatial co-occurrence of any CV spring-run Chinook salmon life stages that may be present and the stressors associated with PA conditions in the San Joaquin River between the confluence of the Stanislaus River and Mossdale.

Life Stage	Life Stage Timing	Stressor	Response	Probable Fitness Reduction
Adult migration	Mar-Sep	Water temperatures warmer than life history stage requirements, primarily in June- September	Failure to enter tributary before temperatures rise at lower river reaches; thermal stress; mortality	Reduced survival; reduced reproductive success; Reduced diversity in life- history timing
Juvenile rearing	Dec-May	Lack of overbank flow to inundate rearing habitat	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival
Juvenile rearing	Dec-May	Reduction in rearing habitat complexity due to reduction in channel forming flows	Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	Reduced growth rates; Reduced survival
Juvenile rearing	Dec-May	Springtime water temperatures warmer than life history stage requirements, primarily March- May	Metabolic stress; starvation; loss to predation; indirect stress effects, poor growth;	Reduced growth rates; Reduced survival
Juvenile out- migration	Nov-May	Water temperatures warmer than life history stage requirements, primarily in May	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress	Reduced survival; Reduced diversity in outmigration timing
Juvenile out- migration	Nov-May	Suboptimal flow	Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	Reduced survival; Reduced diversity in outmigration timing

Many of the flow-related stressors affecting any CV spring-run Chinook salmon that may be in this reach of the San Joaquin River identified in Table 2.5.7-6 are similar to those discussed for CCV steelhead in the Stanislaus River in Section 2.5.6.1.5.1. Water temperatures, however, are separately evaluated below since water temperatures are higher on the San Joaquin River than the Stanislaus and need to be linked to CV spring-run Chinook salmon life-history timing.

Suitable temperatures for each CV spring-run Chinook salmon life stage (with life-stage timing noted) is summarized below in Table 2.5.7-11 and the evaluation of monthly average water temperatures at Vernalis under the PA using these criteria is summarized in Table 2.5.7-12.

Table 2.5.7-11. Salmon temperature requirements by life stage from Table 3 and Table 4 of the U.S. EPA's Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (U.S. Environmental Protection Agency 2003), along with life-stage timing of any CV spring-run Chinook salmon in the San Joaquin River. 7DADM is 7-day average of the daily maximum temperature.

Life Stage & Timing	Temperature Criterion
Salmon juvenile rearing (December - May)	61°F 7DADM
Salmon migration plus non-core juvenile rearing (Combined: November - September)  Adult migration: March - September  Juvenile migration: November - May  Non-core juvenile rearing: December - May	64°F 7DADM
Salmon migration (Combined: November - September) Adult migration: March – September Juvenile migration: November - May	68°F 7DADM

Table 2.5.7-12. Evaluation of water temperature suitability under the PA (panel a) and COS (panel b) for CV spring-run Chinook salmon for various lifestages. Data are modeled monthly water temperatures (not 7DADM), by San Joaquin "60-20-20" year type, under the relevant scenario. Because the modeled monthly temperatures, averaged by water year type, will be lower than the maximum daily temperatures most relevant for evaluating 7DADM criteria, this analysis underestimates temperature-related impacts to any CV spring-run Chinook salmon that may be in this reach of the San Joaquin River. Red shading indicates month/year type combinations in which monthly water temperatures exceed the temperature criterion. Gray shading indicates month/year type combinations in which the lifestage is not expected to be present in the San Joaquin River.

	-	
a)	PA	scenario

Below Normal

Critical

62.2

63.4

65.5

55.7

56.1

56.9

48.6

48.7

49.3

49.1

48.4

48.6

53.1

53.8

54.8

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
			Juve	nile reari	ng (61°F	DADM)	– Decemb	ber - May				
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
		Mig	gration plu	is non-cor	e juvenile	rearing (	54°F 7DA	DM) - ye	ar-round			
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70.3
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76.0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73,3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
				Migrati	on (68°F	DADM)	- year-ro	und				
Wet	62.4	55.9	49.5	48.6	51.9	55.5	59.3	64.8	68.0	72.0	73.8	70:4
Above Normal	63.1	55.4	48.9	48.7	52.7	56.9	59.3	65.4	73.3	77.4	76:0	72.4
Below Normal	62.1	55.6	48.6	49.1	53.2	58.5	60.1	64.0	73.3	78.2	76.4	72.8
Dry	63.4	56.1	48.6	48.3	53.8	58.5	63.7	68.1	75.3	78.4	76.5	73.1
Critical	65.3	56.9	49.3	48.6	54.8	61.1	65.4	69.9	75.5	78.8	77.6	73.7
b) COS scen		NOU	DEG	1437	l ren	1 3640	l ann	LAME			1110	CED
	OCT	NOV	DEC	JAN .	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
***				1				ber - May	<b>50.0</b>	=0.0	=0.0	=0.4
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73.1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68 7	74.9	78.3	77.1	73.6
						1		DM) ye				
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3
Below Normal	62.2	55.7	48.6	49.1	53.1	58.4	60.3	64.2	72.2	78.1	76.4	72.8
Dry	63.4	56.1	48.7	48.4	53.8	58.5	63.0	66.8	74.8	78.3	76.5	73:1
Critical	65.5	56.9	49.3	48.6	54.8	61.1	64.6	68.7	74.9	78.3	77.1	73.6
			T works		on (68°F	1	- year-ro					
Wet	62.4	55.9	49.5	48.6	52.0	55.6	59.3	64.8	68.3	72.2	73.8	70.4
Above Normal	63.2	55.4	48.9	48.7	52.7	56.9	59.6	65.7	70.4	76.6	75.8	72.3

Water temperatures at Vernalis are most unsuitable for rearing in April and May, and unsuitable in March as well during drier years. Water temperatures at Vernalis are likely to be stressful to any outmigrating CV spring-run Chinook salmon that may be in this reach of the San Joaquin

58.4

58.5

61.1

60.3

63.0

64.6

64.2

66.8

River, or even serve as a barrier to migration, in May through September, and in April during drier years.

# 2.5.7.1.2.3 CV Spring-run Chinook Salmon Risk

Based on the effects to any CV spring-run Chinook salmon that may be in this reach of the San Joaquin River associated with the PA Conditions described above, fitness consequences to individuals include reduced survival and growth during juvenile rearing, and reduced survival and growth during juvenile outmigration (see

Table 2.5.7-10). Additionally, conditions may restrict the window of successful outmigration of individuals and thus reduce the diversity of outmigration timing for any CV spring-run Chinook salmon in the San Joaquin River basin.

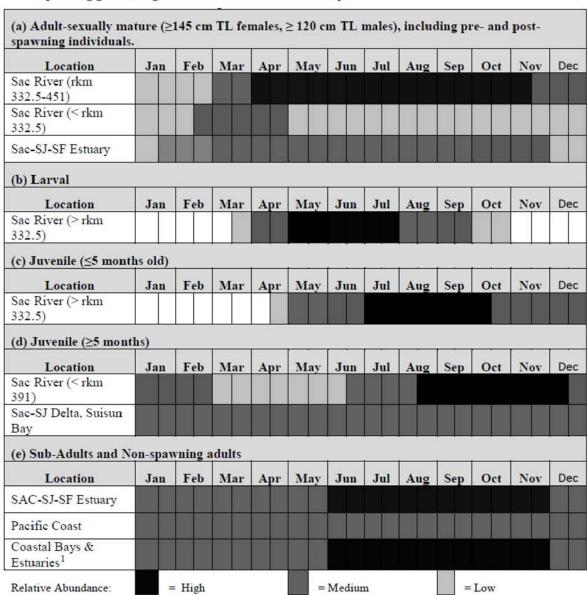
# 2.5.7.1.3 sDPS Green Sturgeon Exposure, Response, and Risk

Catch of sDPS green sturgeon in the San Joaquin River on Sturgeon Fishing Report Cards²⁵ and the verified observation of an sDPS green sturgeon on the Stanislaus River (Anderson et al. 2018) indicate opportunistic use of the San Joaquin River basin when conditions are favorable. No spawning on the San Joaquin River has been verified. Life history timing of sDPS green sturgeon adults and juveniles in this reach of the San Joaquin River is described in Table 2.5.7-13 and Table 2.5.7-14.

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²⁵ Available at: http://www.dfg.ca.gov/delta/data/sturgeon/bibliography.asp

Table 2.5.7-13. The temporal occurrence of (a) spawning adults (see row for "Sac-SJ-SF Estuary"), (b) larval, (c) young juvenile, (d) juvenile (see row for "Sac-SJ Delta, Suisun Bay"), and (e) sub-adult/non-spawning green sturgeon in California's Central Valley.



Sources: (a) Heublein et al. 2008; Klimley et al. 2015; Poytress et al. 2015; Mora et al. 2015; (b) Poytress et al. 2015; Heublein et al. in review; (c) Heublein et al. in review; B. Poytress unpublished; (d) Radtke 1966; CDFG 2002; Heublein et al. in review; B. Poytress unpublished; (e) Erickson and Hightower 2007; Moser and Lindley 2006; Lindley et al. 2008; Lindley et al. 2011; Huff et al. 2011. Outside of Sac-SJ-SF estuary (e.g. Columbia River, Grays Harbor, Willapa Bay).

Table 2.5.7-14. Summary of green sturgeon catch and length statistics from Sturgeon Fishing Report Cards for observations in the San Joaquin River from Stockton to the Highway 140 Bridge. Seasons were defined as follows: Winter = December-February, Spring = March-May, Summer = June-August, Fall = September-November.

Report Card Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	TOTAL
Number of		- :										f.
Anglers	-	8	13	-	-	-	-	2	-	-	1	24
Winter Catch	-	1	4	-	-	-	-	1	-	-	-	6
Spring Catch	-	7	10	-		-	-	-	-	-	1	18
Summer Catch	-	0	-	14	-	-	-	-	-	-	-	0
Fall Catch	-	1	2	-	-			1	-	-	1	5
Total Catch	-	9	16	-	-	-	-	2	-	-	2	29
Number												
Measured	-	9	16	-	-	~	-	-	-	-	-	25
Minimum												
Length (inches)	-	49.0	47.0	-			-	-	-	-		
Maximum												
Length (inches)	:=	66.0	62.0	3=1	-	-	-	-	-	-	-	
Average Length												
(inches)	(6)	58.1	54.3	-	-	9	-	-	3	-	-	

Data sources: (California Department of Fish and Game 2008, Gleason et al. 2008, California Department of Fish and Game 2009, 2010a, 2011, 2012, California Department of Fish and Wildlife 2013a, 2014a, 2015a, 2016a, 2017a, DuBois and Danos 2018)

SDPS green sturgeon presence and behavior in the San Joaquin River is poorly understood and use of this reach of the San Joaquin River is likely opportunistic. Operations under the PA Conditions could lead to changes in the stressors identified in Table 2.5.7-2; mechanisms and probable change in fitness would generally be similar to those discussed in the Sacramento Division and Delta Division analyses for green sturgeon.

#### 2.5.7.2 Conservation Measures

#### 2.5.7.2.1 Lower San Joaquin River Habitat

The ROC on LTO BA describes the "Lower SJR Rearing Habitat" conservation measure as "Reclamation may work with private landowners to create a bottom-up, locally driven regional partnership to define and implement a large-scale floodplain habitat restoration effort in the Lower San Joaquin River. ... Such a large scale effort along this corridor would require significant support from a variety of stakeholders, which could be facilitated through a regional partnership." NMFS supports both regional partnerships and multi-benefit floodplain habitat restoration projects in the San Joaquin basin and expects that such a project would provide benefits to CCV steelhead and any CV spring-run Chinook salmon that may be in this reach of

the San Joaquin River and could provide benefits to juvenile sDPS green sturgeon²⁶. Acknowledging that the full scope of the effort is outside Reclamation and DWR's discretion and would require regional partners, in this Opinion, NMFS considers the benefits of this proposed conservation measure at the framework level.

#### 2.5.8 Effects of the Action on Southern Resident Killer Whales

The primary potential impact of the PA on SRKW that has been identified in the ROC on LTO BA (U.S. Bureau of Reclamation 2019) and in this Opinion is through potential reductions in availability of preferred prey, Chinook salmon, in the coastal waters where Chinook salmon from the Central Valley of California may be encountered by SRKW.

The Quantity and Quality of Prey portion of the Factors Affecting the Prey of SRKW in the Action Area section (Section 2.4.7.4) describes the evaluation by the Science Panel (Hilborn et al. 2012) of the state of the science of the effects of salmon fisheries on SRKW. While there is uncertainty in the extension of the statistical correlations to precise predictions of the effect of Chinook salmon abundance on the SRKW population, to date there are no data or alternative explanations that contradict fundamental principles of ecology that wildlife populations respond to prey availability in a manner generally consistent with the analyses that link Chinook salmon abundance and SRKW. As a result, and based on evidence discussed in the Rangewide Status of the Species section (Section 2.2.9 and Appendix B) and the Factors Affecting the Prey of SRKW in the Action Area section (Section 2.4.7.4), NMFS concludes that the best available science suggests that relative Chinook salmon abundance in the ocean throughout their range and any changes in prey availability resulting from natural and man-made factors are likely to influence the SRKW population.

# 2.5.8.1 Impacts to the Abundance of Chinook as a Result of the Proposed Action

#### 2.5.8.1.1 Central Valley Chinook Salmon Abundance and Productivity

#### 2.5.8.1.1.1 Escapement of Central Valley Chinook salmon

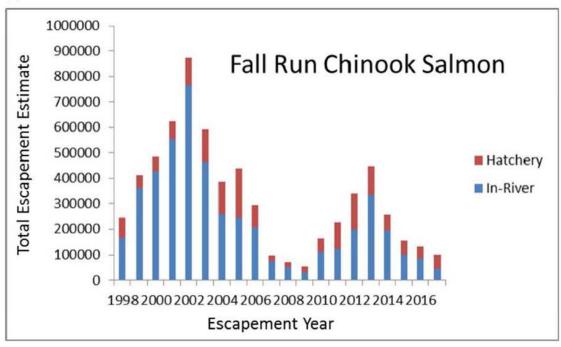
In terms of productivity and abundance, the vast majority of CV Chinook salmon is comprised of non-ESA-listed fall-run Chinook salmon, and to a lesser degree non-ESA-listed late fall-run Chinook salmon and ESA-listed populations of CV spring-run Chinook salmon, and least of all ESA-listed winter-run Chinook salmon. This is reflected in estimates of annual spawning escapement for the Sacramento and San Joaquin rivers and their associated tributaries provided by CDFW; fall-run Chinook salmon escapement estimates are typically on the order of several hundred thousand adults, compared to tens of thousands each for late fall-run and CV spring-run Chinook salmon, and several thousand adults for winter-run Chinook salmon (CDFW 2018 GrandTab; Figure 2.5.8-1).

Our approach to analyzing the effects of the PA on SRKW in this Opinion includes analysis of impacts to fall-run and late fall-run Chinook salmon, in addition to impacts to ESA-listed winter-

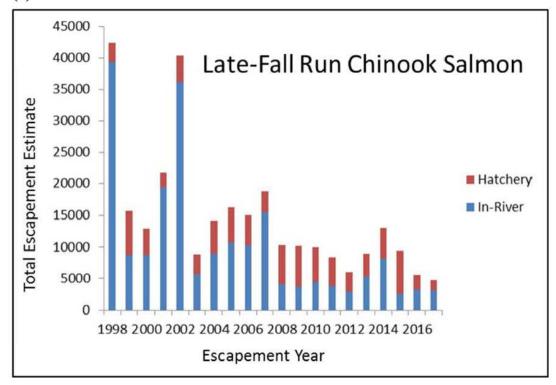
²⁶ Green sturgeon presence and behavior in the San Joaquin River is poorly understood and floodplain rearing has not been documented. However, there are a number of benefits that floodplain habitat could provide juvenile green sturgeon such as increased growth opportunity and refuge from predators.

run and CV spring-run Chinook salmon in the Central Valley since individuals from all populations are potential prey for SRKW along the U.S. West Coast.

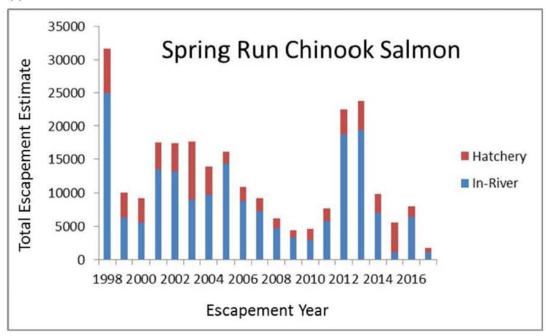
(a)



**(b)** 







# (d)

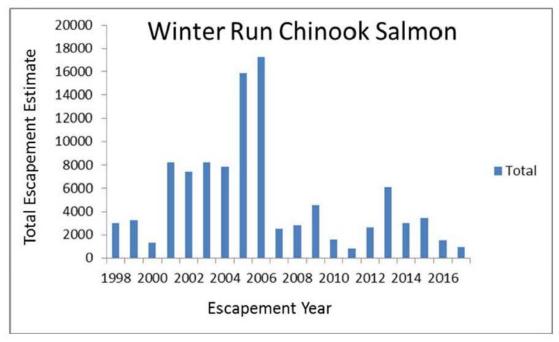


Figure 2.5.8-1. Total annual escapement of adult Chinook Salmon to river systems in the Central Valley from 1998-2017 for each run of Chinook salmon, distinguished by escapement totals back to natural production areas in-river and to hatchery areas, as appropriate. (a) Fall-run Chinook salmon; (b) Late fall-run Chinook salmon; (c) CV spring-run Chinook salmon; and (d) winter-run Chinook salmon. Source data: CDFW 2018 GrandTab

Over the last 20 years (1998-2017), the total annual adult escapement of each Chinook salmon run in the Central Valley has varied considerably; especially the total annual escapement for the predominant fall-run Chinook salmon population which has ranged from just over 50,000 adults to almost 900,000 adults during that time period. Using analysis of variance (ANOVA) linear regression, trends indicate that the average total annual adult escapement has significantly declined over the last 20 years for fall-run Chinook salmon (F=8.54;  $\alpha$ =0.009), late fall-run Chinook salmon (F=4.59;  $\alpha$ =0.046). The trend for winter-run Chinook salmon over this time is negative as well, but not significantly so (F=1.99;  $\alpha$ =0.175).

There are likely many factors that contribute to the trends in abundance and productivity of CV Chinook salmon, including variation in natural and human-caused mortality and other influences on the quantity and quality of available habitat, survival, and ultimate reproductive success throughout their life cycle in both the freshwater and marine environment (Michel 2018). As described in Section 2.2 Rangewide Status of the Species, Appendix B, and Section 2.4 Environmental Baseline for ESA-listed Chinook salmon, these include significant influences such as harvest, hatchery production, and habitat alterations. Included among the major influences for all Chinook salmon in the Central Valley is the ongoing operation of water projects that are subject to consultation as part of this PA.

# 2.5.8.1.1.2 Hatchery Production

The production and release of hatchery Chinook salmon of different run-types from various hatcheries represents a substantial proportion of overall Chinook salmon productivity in the Central Valley. Table 2.5.88-2.5.8-1 describes the general release goals for each Central Valley hatchery and run-type, as well as the average proportions of releases made directly in-river and releases transported directly into San Francisco Bay based on production and release activity 2007-2013 (Palmer-Zwahlen et al. 2019 and 2018, and Palmer-Zwahlen and Kormos 2015). The number of hatchery-produced fish released each year for all CV Chinook salmon runs combined during that time averaged 35,059,237; ranging from 30,455,664 to 38,510,728 (Appendix L). The proportion of hatchery fish released in-river and in the Bay varies from year to year based on water year conditions and other factors.

Table 2.5.88-2.5.8-1. Central Valley Chinook salmon hatchery release goals and proportion released in-river and in Bay areas.

Hatchery annual Chinook	General		Proportion	Number in-
releases	goal	Proportion bay	in-river	river
Coleman fall	12,000,000	0	1	12,000,000
Coleman late fall	1,000,000	0	1	1,000,000
LSNFH Winter	200,000	0	1	200,000
Feather Fall	6,000,000	0.7	0.3	1,800,000
Feather Spring	2,000,000	0.5	0.5	1,000,000
Feather enhancement	2,000,000	1	0	0
Nimbus	4,000,000	0.33	0.67	2,680,000
Mokelumne	5,000,000	0.7	0.3	1,500,000
Mokelumne enhancement	2,000,000	1	0	0
Merced	300,000	0	1	300,000
Total release	34,500,000			
In-river release	20,480,000			
Proportion released in-river	0.59			

Analysis of Chinook salmon otoliths in 1999 and 2002 found that the contribution of hatchery-produced Chinook salmon made up approximately 90 percent of the ocean fishery off the central California coast from Bodega Bay to Monterey Bay (Barnett-Johnson et al. 2007). More recently, estimates based on data from the 2012-2014 Central Valley coded wire tag recovery indicated the proportion of CV Chinook salmon in the ocean associated with hatchery proportion in was 70 percent (Palmer-Zwahlen et al. 2019, Palmer-Zwahlen et al. 2018, and Palmer-Zwahlen and Kormos 2015). The large influence of hatchery fish on the productivity of CV Chinook salmon likely results from numerous factors that may include decreased survival rates of natural production in the system, and increasing survival rates of hatchery production as hatchery release practices have been modified over time to improve survival of hatchery fish through the system (e.g., release of hatchery production directly into San Francisco Bay to avoid the Delta). Consequences of this increasing influence of hatchery production include increasing the number of returning adults that stray to non-natal watersheds, further diminishing the genetic integrity of those watersheds' natural population, which likely weakens the viability of the natural stocks to persist.

#### 2.5.8.1.2 Effects of the Proposed Action on Chinook Salmon Individuals

Detailed descriptions regarding the exposure and response of individuals from each of the ESA-listed Chinook salmon ESUs found in the action area and affected by the PA (winter-run Chinook salmon and CV spring-run Chinook salmon) to stressors associated with the PA are described in Section 2.5 *Effects of the Action* (and summarized in Section 2.8 *Integration and Synthesis*). Given that the potential effect of the PA on SRKW is mediated through reduced prey availability associated with effects to all Chinook salmon runs in the Central Valley affected by the PA, the effects analysis for SRKW needs to include analysis of effects to all Chinook salmon populations in the Central Valley that are affected by the PA, including non-listed populations.

#### 2.5.8.1.2.1 Winter-run Chinook salmon

As described elsewhere (by Division) in Section 2.5 and shown in Table 2.8.1-1 in the Integration and Synthesis section, PA-related stressors for winter-run Chinook salmon are expected to reduce the fitness of individuals during the adult, egg, fry, and juvenile life stages. While the entire suite of adverse and potentially beneficial effects associated with the PA are described in Section 2.5 and summarized in Table 2.8.1-1, focus in this section is placed on water temperature management, operations of the DCC gates, and Delta export operations, because among all the CVP/SWP operational components, these have the largest effects on winter-run Chinook salmon viability. While the modeling results suggest that the PA would protect winter-run Chinook salmon eggs better than under COS (see Table 2.5.2 3 for a comparison of the actual current operations to the COS and PA for major CVP action components), there is a high amount of uncertainty with that conclusion. For example, depending on how the fall Delta smelt habitat PA component is implemented, the modeled Shasta storage gains (which assume no augmentation of Delta outflow in the fall) that are primarily responsible for the improvements in egg-to-fry survival may not be realized under real-world implementation of the PA. Regardless of whether the PA improves egg survival relative to current operations, the PA is expected to result in concerning levels of winter-run Chinook salmon mortality. DCC gates could be open for up to 5 days for up to two events in December through January, but only if drought conditions are observed (i.e., fall inflow conditions are less than 90 percent of historic flows), and after Reclamation and DWR coordinates with USFWS, NMFS and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements. If the gates are opened in December or January (expected in less than 1 in 10 years), a substantial proportion of the juvenile winter-run Chinook salmon cohort could enter the migratory routes through the Delta interior and be subject to a much lower rate of survival. Based on projected loss under the PA, thousands of winter-run Chinook salmon juveniles are expected to be lost at the south Delta export facilities under the PA in almost every water year type. Export operations modify hydrodynamics in the south Delta and may lead to far-field migratory impacts as well, particularly in the Old and Middle River corridors, which would negatively affect winter-run Chinook salmon in those corridors. Reduced survival for juveniles from routing changes and increased transit time resulting from operation of the DCC is also listed as high magnitude stressor for winter-run Chinook salmon.

# 2.5.8.1.2.2 CV Spring-run Chinook salmon

As described elsewhere (by Division) in section 2.5 and summarized in Table 2.8.2-2, PA-related stressors are expected to reduce the fitness of CV spring-run Chinook salmon individuals during all life stages. Therefore, each life stage will be harmed to some degree by the PA, with lethal impacts expected to eggs, fry, and juveniles. The most significant PA-related stressors to CV spring-run Chinook salmon are those that are related to water temperature management, operations of the DCC gates, and Delta export operations. Water temperatures unsuitable for life-stage requirements are expected to occur under the PA in the Sacramento River below Shasta Dam. Tiered temperature management based on a presumed critical period for winter-run Chinook salmon eggs and fry, and sublethal effects to holding and spawning CV spring-run Chinook salmon eggs and fry, and sublethal effects to holding and spawning CV spring-run Chinook salmon adults. Under the PA, DCC gates may be operated in less than 1 in 10 years for water quality control management in December and January (see above discussion for winter-run Chinook

salmon). DCC gate opening results in increased routing of migrating Chinook salmon into the Delta interior through the open DCC gates, where survival is reduced. The more negative OMR flows predicted under the PA are a direct response to increased exports, particularly in April and May. This action potentially affects all life stages of CV spring-run Chinook salmon, and increases the risk of entrainment, particularly juveniles, into the export facilities, increasing the risk of mortality to exposed fish (see Table 2.8.1-3). Export operations modify hydrodynamics in the south Delta and may lead to far-field migratory impacts as well, particularly in the Old and Middle River corridors, which would negatively affect CV spring-run Chinook salmon in those corridors.

#### 2.5.8.1.2.3 Fall-run and Late Fall-run Chinook salmon

In general, all of the stressors that exist for CV spring-run and winter-run Chinook salmon also exist for CV fall-run and late fall-run Chinook salmon in the action area. We recognize there are differences how various Chinook salmon ESUs are exposed to the stressors based on variations in run timings, locations within the system where migrations and spawning may occur, and how/where the PA impacts the system in relation. In some cases, the exposure and response of fall-run and late fall-run Chinook salmon to certain stressors may be more or less given these variations, and in some cases the exposure and response is likely very similar.

For example, increased exports under the PA in April and May coincide with the majority of fall-run and late fall-run Chinook salmon emigrating through the Delta region. The proposed increase in exports will increase the number of fish from these populations entrained into the fish collection facilities as indicated by the substantial increases in loss predicted using the salvage density model. Increased exports under the PA operations will increase the number of fish lost during the salvage process, as more fish are entrained from the surrounding Delta waterways. Export operations modify hydrodynamics in the south Delta and may lead to far-field migratory impacts as well, particularly in the Old and Middle River corridors, which would negatively affect fall-run and late fall-run Chinook salmon in those corridors. Likewise, as in the COS, under the PA the DCC gates begin to be intermittently operated starting May 21, and generally fully open by mid-June, which would allow late emigrating fall-run Chinook salmon from the Sacramento River basin to be routed into the Delta interior, where their survival is predicted, based on previous studies, to be substantially lower.

## 2.5.8.1.3 Effects of the Proposed Action on Chinook Salmon Populations

In this Opinion, we have not conducted identical analysis of each stressor on non-ESA-listed Chinook salmon populations throughout the action area. Given that the potential impact of the PA on SRKW is on the availability of all potential Chinook prey sources from the Central Valley, we will focus on the overall impact of the proposed action on Chinook productivity from the entire system and ultimate abundance of CV Chinook salmon in the ocean that may be available as prey for SRKW using available information that characterizes overall population levels effects of the proposed action. To do this, we consider the available quantitative and qualitative information that describes the underlying and ongoing effects of water operations on Chinook salmon populations under the proposed action. Where possible, we explore this Chinook salmon population level analysis quantitatively drawing upon available models of sources of mortality related to the proposed project in comparison to the COS to gauge how productivity is affected by the operational changes that have been proposed. Finally, where

necessary, we consider additional qualitative assessment of stressors that cannot be captured directly through these models.

#### 2.5.8.1.3.1 Winter-run Chinook Salmon

As described in section 2.5 and summarized in Table 2.8.1-1, habitat conditions in the Sacramento River and Delta are adversely affected by the PA in a number of ways, including but not limited to: (1) releasing warm water temperatures for eggs in all years, resulting in particularly high mortality in drier years; (2) decreasing flows during the juvenile rearing period, which increases the likelihood that juveniles using floodplain and side-channel habitats when flows are high will be isolated from the river when flows are decreased; and (3) routing more water and juvenile salmon into the Central and South Delta, and into the export facilities, which creates detrimental outmigration conditions and decreased survival by increasing the exposure of juveniles to predation and poor water quality. In these ways, the PA reduces habitat quantity and quality, which increases the risk of extinction of the winter-run Chinook salmon population, and consequently the ESU. As described in Section 2.5.9, results from the winter-run Chinook salmon life cycle model (WRLCM) support that expectation by indicating that while the WRLCM shows a very slight increase in CRR for the PA, the abundance for PA operations is on average less than for the COS. The effects of the operations of the PA would not increase abundance or productivity of winter-run Chinook salmon, but assumes that results would be similar to those of current operations.

## 2.5.8.1.3.2 CV Spring-run Chinook salmon

As described in section 2.5 and Table 2.8.3-2, conditions in the Sacramento River and the Delta for CV spring-run Chinook salmon are negatively affected by the PA by delaying adult immigration through the DCC operations, affecting water temperatures that are stressful to CV spring-run Chinook salmon, entrainment of juveniles into the Central and South Delta and at fish salvage facilities. Spawning and egg incubation habitat for CV spring-run Chinook salmon in the mainstem Sacramento River is often adversely affected by operation of the CVP through warm water releases from Shasta Reservoir. The PA produces stressors to spawning, rearing, and migratory habitats in the mainstem Sacramento River. Those stressors include changes in water temperature management, exposure to warm water temperatures during egg incubation and juvenile rearing, increased exports, and loss of natural river function and morphology, affecting all habitat types and rearing habitat quantity and quality in particular. In these ways, the PA reduces habitat quantity and quality, which increases the risk of extinction of CV spring-run Chinook salmon populations, and consequently the ESU.

Under the PA, DCC gates may be operated more frequently for water quality control management in December and January. When this operation occurs (expected in less than 1 in 10 years), listed fish may route into the interior Delta through the open DCC gates. During the months of potential DCC gate operation in December and January, approximately 5 percent of the current brood year's juvenile CV spring-run Chinook salmon population has migrated into the upper Delta region adjacent to the location of the DCC gates and may be subjected to routing into the Delta interior where survival is reduced compared to remaining in the Sacramento River migratory route. Reclamation also proposed to increase exports at the CVP and SWP during drier years from February through June and in all water year types in April and May in the original PA (Appendix A1). Delta exports potentially affect all life stages and populations of CV spring-run

Chinook salmon, and increasing exports increases the risk of entrainment (particularly juveniles) into the export facilities, increasing the risk of mortality to exposed fish (see Table 2.8.3-2). The salvage density modelling showed that the increased exports under the PA will lead to more loss at the CVP and SWP (loss is 4.33 times salvage, on average, at SWP, and 0.66 times salvage at the CVP). There are expectations for revised PA elements such as OMR management and performance objectives intend to limit impacts (i.e., salvage loss) under the PA to levels comparable to what would occur under the COS. However, as described in 2.5.8.2 Supplemental Analysis of June 14, 2019, there are some uncertainties in how new approaches will be implemented and uncertainties associated with effects.

#### 2.5.8.1.3.3 Fall-run and Late fall-run Chinook Salmon

In the NMFS 2009 Opinion, we analyzed freshwater mortality sources that included high water temperature and low flow upstream, and direct entrainment in the Delta, to evaluate an overall change in freshwater mortality for CV fall-run and late fall-run Chinook salmon attributed to project operations. Impacts from project operations that were not included in our assessment were mortality from fish stranding, redd dewatering and predation. In 2009, we determined that Project operations in the Central Valley reduced the total abundance of hatchery and natural CV fall- and late fall-run Chinook salmon available to SRKW compared to other basic operation scenarios by between 1.9 and 2.3 percent annually (average) over the project duration (range: 1.1 to -13.5 percent), although we identified interrelated and interdependent hatchery production that offset those overall losses at that time (National Marine Fisheries Service 2009b). Because natural-origin salmon are important to the long-term maintenance of salmon population distribution and diversity, both important factors for retaining population viability (McElhany et al. 2000) and buffering environmental variation (Lindley et al. 2009), we also quantified the prey reduction specific to natural-origin fall and late fall-run Chinook salmon in the SRKW analysis. We determined that project operations in the Central Valley reduced the abundance of naturalorigin fall and late fall-run Chinook salmon compared to a "maximum salmon production" scenario by between 9.8 and 10.7 percent annually (average) over the project duration (range: -0.7 percent to -41.9 percent), depending in part on environmental variability (National Marine Fisheries Service 2009b).

During consultation on this PA, there has not been an update to these analyses of overall impacts of water operations on the productivity of non-ESA listed CV Chinook salmon provided (see below for comparison of current operations following the NMFS 2009 Opinion and the PA). We recognize that the NMFS 2009 Opinion contained numerous RPA actions designed to avoid jeopardy to ESA-listed Chinook salmon species, as well as measures that were expected to benefit non-ESA-listed Chinook salmon species, and ultimately the prey base of SRKW. At this time, it is unclear if there have been significant changes in the impact of water operations on the productivity and overall survival of CV fall-run and late fall-run Chinook salmon as a result of RPA implementation, changes in the status of these Chinook salmon populations, or other factors. Without any more specific information, we assume that water operations under the PA will continue to reduce the productivity of both ESA listed and non-listed Chinook salmon each year and have significantly higher impacts to natural origin fall- and late fall-run Chinook salmon that can be especially acute during some years when environmental stress on the Central Valley system is greatest. We also assume that other sources of mortality associated with water

project activities that remain unquantified further continue to exacerbate the reduction and limitation of productivity of both ESA listed and non-listed CV Chinook salmon.

#### 2.5.8.1.4 Changes in Chinook Salmon Productivity under the PA compared to COS

During this consultation, analyses of the relative change in Chinook salmon productivity for all CV Chinook salmon populations (ESA listed and non-listed) under the PA compared to current operations (COS) was provided. Ultimately, these results were used to assess the relative change in the number of adult Chinook salmon in the ocean available as prey for SRKW under the COS. The complete analyses are presented as SRKW Prey Appendix L to this Opinion; here we will summarize the analyses and key results.

## 2.5.8.1.4.1 Upstream Sacramento River

The Salmod model (Bartholow 2003) was used to estimate effects to fall-run, late fall-run, and CV spring-run Chinook salmon in the Sacramento River upstream of Red Bluff. Factors in the model affecting survival include water temperature effects on each life stage present in the upper Sacramento River (adult through emigrating juveniles), flow versus spawning habitat area relative to adult spawner distribution, flow versus rearing habitat area relative to juvenile fish distribution, and the adult escapement input to the simulation. Redd dewatering is a factor not assessed in the Salmod model, and is a potentially significant stressor to fall-run Chinook salmon in particular.

Results for Sacramento River fall-run Chinook salmon show a median change in production (outmigrants past Red Bluff) under the proposed action compared to COS of -0.34 percent (average is -1.19 percent) with a range of -30 percent to 17 percent change over the CalSimII simulation period (82 years: 1920-2002). Salmod estimates that late fall-run Chinook salmon productivity would have a medium change under the PA compared to COS of -0.68 percent (average is -0.15 percent) with a range of -12.7 percent to 8.7 percent. The median change in productivity under the PA compared to COS for CV spring-run Chinook salmon is -1.08 percent (average is 3.1 percent increase) with a wide range in both the positive and negative directions (-100 percent to 600 percent), acknowledging that CV spring-run Chinook salmon abundance/productivity in the upper Sacramento River is small and variations appear relatively large in comparison (Table 2.5.8-2; Appendix L).

Table 2.5.8-2. Change in survival from COS to PA scenarios for each Central Valley (CV) Chinook salmon population, by area, and model source of estimate. The relative proportion of total CV escapement for each population is also provided. Negative values indicate a decrease; positive values indicate an increase. Note: for winter-run Chinook salmon the IOS model is applied for ocean abundance and incorporates freshwater survival factors.

River and run	Upstream effects - Egg Mortality Model			Upstream effects - Salmod juvenile production			Delta effects - Delta Passage Mode l			Lifecycle effects - IOS			Proportion of CV Abundance
Miver and Fan	The state of the s		2.5 %ile			_		median 97.5 %ile					-
Sacramento River winter-run										0.015			
Sacramento River spring-run				-0.0108	151.8044	-99.787	-0.0051	0.015145	-0.014				0.0003
Sacramento River fall-run				-0.0034	0.0734	-0.2004	-0.0032	0.021709	-0.017				0.0970
Sacramento River late fall-run				-0.0068	0.0807	-0.0787	-0.0023	0.008336	-0.0715				0.0259
Clear Creek fall and spring-run							-0.0032	0.021709	-0.017				0.0228
American River fall-run	-0.0001	0.0389	-0.0333				-0.0032	0.021709	-0.017				0.2233
Stanislaus River fall-run	0.0037	0.1542	-0.1042										0.0099
Feather River fall and spring-run							0.0032	0.016971	-0.0217				0.2397
Other Sac Runs (spring)							-0.0051	0.015145	-0.014				0.0218
Other Sac Runs (fall)							-0.0032	0.021709	-0.017				0.2915
San Joaquin Basin		not evaluated								0.0264			
Mokelumne					no	t evaluate	ed						0.0284

#### 2.5.8.1.4.2 Sacramento River Winter-run Chinook Salmon

Effects of the PA on the relative productivity of winter-run Chinook salmon were quantified using the IOS model (Section 2.5.9). IOS is a lifecycle model that provided an estimate of the change in life stage survival and ultimate ocean abundance and escapement throughout the CalSimII simulation period. In the upper Sacramento River the model integrates the effects of temperature, flow, fish abundance, and habitat availability to arrive at production of juvenile winter Chinook salmon emigrating down the Sacramento River, through the Delta, and to the ocean. Ocean survival factors are included through the range of years in the ocean until the fish come back and spawn. IOS differs from the Salmod model in that it includes the entire lifecycle with each generation seeding fish to the next.

The change in abundance from the beginning to the end of the simulation period from a starting abundance of 5,000 escapement used to seed the model in the first four years showed a 92 percent increase in ocean abundance (age 3 and 4) for COS and a 125 percent increase for PA. The difference in median ocean abundance between the two scenarios was a 1.5 percent increase in abundance in PA compared to COS (Table 2.5.8-2; Appendix L).

In contrast, the Winter-run Life Cycle Model (WRCLM) developed by NMFS, estimated a decrease in abundance (-3.05 percent) between the PA and COS, with a 95 percent confidence interval of -8.07 to 0.137 percent change in productivity. There was less than a 0.03 percent chance that the PA average abundance was greater than the average abundance in the COS. Typically the WRLCM predicted lower smolt survival based on habitat origin, except for wet water year conditions, where greater survival of smolts utilizing the Yolo Bypass during the January through March period enhanced overall survival under the PA compared to the COS.

# 2.5.8.1.4.3 American River

The Salmort egg survival model (DWR and Reclamation 2016) was used to estimate the change in fall-run Chinook salmon survival from the American River from changes in early lifestage survival attributable to water temperature. This model uses the water temperature model outputs along with Chinook salmon spawning distribution and abundance to estimate water temperature

effects to pre-spawned eggs, incubating eggs, and alevins. Survival is decreased slightly (median value of -0.012 percent) under the PA compared to COS. During most years in current and future scenarios the effect of high water temperature on egg survival is significant, ranging from around 15 percent – 35 percent mortality due to water temperature (Table 2.5.8-2; Appendix L).

#### 2.5.8.1.4.4 Stanislaus River

The Salmort egg mortality model was used to estimate water temperature related mortality of early life stages of fall-run Chinook salmon in the Stanislaus. Mortality is typically decreased under the PA compared to COS in a majority of years, but in about 10 percent of years mortality is estimated to be higher under the PA (Table 2.5.8-2; Appendix L). Water temperatures during spawning are reduced on average and New Melones storage is maintained at a higher level in PA, although egg survival is probably not the most limiting factor in the Stanislaus (Appendix L).

#### 2.5.8.1.4.5 Clear Creek

There were no appreciable differences in water temperature in Clear Creek or release from Whiskeytown Dam into Clear Creek to compare between the PA and COS; therefore, no modeling of change in fall-run or CV spring-run Chinook salmon survival in Clear Creek was conducted.

# 2.5.8.1.4.6 Overall Central Valley Upstream Productivity

In order to calculate the overall change in upstream survival and productivity for all CV Chinook salmon under the PA compared to COS, the change in upstream survival for each Chinook salmon population described above (with the exception of winter-run Chinook salmon life cycle model results) was scaled by the relative proportion of CV Chinook salmon productivity represented by each population through escapement totals in Grand Tab (Appendix L; CDFW 2018). The median aggregate change in survival from upstream areas was a slight reduction (-0.05 percent) for PA compared to COS, and a 97.5 percentile to 2.5 percentile range from an increase of over 6 percent to a decrease of 6 percent. This value represents expected change in upstream survival and productivity for natural production from all upstream areas that were modeled, in total.

#### 2.5.8.1.4.7 Delta Survival

The Delta Passage Model (Cavallo et al. 2011) was used to estimate survival of fall-run, late fall-run, and CV spring-run Chinook salmon from the Sacramento River side emigrating through the Delta. This model uses results from acoustic tagged salmon survival studies along with relationships between flow and routing through delta channels and survival rate to estimate through-Delta smolt survival.

Results for fall-run and CV spring-run Chinook salmon indicate that both populations will experience slight reductions in productivity as a result of reduced through-Delta survival under the PA compared to COS; -0.3% and -0.5% change in median survival rates, respectively (Table 2.5.8-2; Appendix L). Late fall-run Chinook salmon show more years with reduced through-Delta survival than increased survival and a median reduction of 0.2 percent under the PA compared to COS (Appendix L). Since the Delta Passage Model does not incorporate data from

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the San Joaquin River basin into its development, no Delta survival changes were modeled for Chinook from the San Joaquin or Mokelumne rivers.

A total reduction in CV Chinook salmon productivity as a result of reduced through-Delta survival under the PA compared to the COS was calculated in a similar manner as the upstream aggregated upstream productivity by weighting each CV Chinook salmon population by their relative proportions of overall escapement. The overall median change in delta survival under the PA compared to COS was -0.0014 with 2.5 percentile to 97.5 percentile values ranging from -0.0181 to 0.0184, so the range is less than a 2 percent change in the positive or negative directions (Appendix L).

### 2.5.8.1.4.8 Hatchery Production and Survival to San Francisco Bay

Hatchery-produced Chinook salmon releases are included in the analysis by using the average release of hatchery juveniles for 2007 - 2013 for all CV Chinook salmon runs combined (average total of 35,059,237; Table 2.5.8-1), and the average in river release proportion (0.59; Table 2.5.8-1). In-river mortality was applied to the in-river released hatchery fish using a static river survival value for survival from release to the delta of 0.5 that comes from acoustic telemetry survival studies using late fall-run Chinook salmon (National Marine Fisheries Service 2019d). The Delta Passage Model was used to estimate Delta survival for the COS and PA scenarios for all hatchery produced Chinook salmon that travel through the Delta (Appendix L). The resulting median change in survival for hatchery produced Chinook salmon released in-river to San Francisco Bay under the PA is 0.003, which leads to a median change of -1.5 percent in the number of juveniles that survive to San Francisco Bay (Appendix L). Finally, the in-river released hatchery Chinook salmon surviving through the Delta were added to the number of hatchery fish released directly into San Francisco Bay to calculate the total number of hatchery Chinook salmon that make it into San Francisco Bay (Appendix L). The resulting median change in productivity for all Central Valley hatchery production into San Francisco Bay under the PA is that 0.2% less hatchery produced juveniles survive to San Francisco Bay under the PA compared to COS (Appendix L).

# 2.5.8.1.4.9 Combined Upstream and Delta Survival to San Francisco Bay for Natural Production

Aggregate freshwater survival change under the PA compared to COS is based on the upstream change in survival multiplied by change in Delta survival under the PA, resulting in an overall median PA value of 0.999 of the COS value with the 2.5 percentile to 97.5 percentile values of 0.982 to 1.018 (Appendix L).

# 2.5.8.1.4.10 Linking Hatchery and Natural Production in San Francisco Bay to Ocean Abundance

In order to relate the comparative impact of the PA to COS in terms of the overall ocean abundance of CV Chinook salmon, we first examined the relative contribution of hatchery production (released in-river and directly into San Francisco Bay as described above) and natural production to recent ocean abundances of CV Chinook salmon, in order ultimately relate the relative impact of the PA compared to COS to each component as described above. The hatchery and natural proportions of CV Chinook salmon were estimated based on data from the 2012-

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2014 Central Valley coded wire tag recovery reports (Palmer-Zwahlen et al. 2019, Palmer-Zwahlen et al. 2018, and Palmer-Zwahlen and Kormos 2015). Over these years, the proportion of fish recovered that were of hatchery origin averaged 0.70 (range 0.65 – 0.75). Using the median ocean abundance of CV Chinook salmon for the period 2001 – 2018 of 454,052 (age 3+), along with the assumed hatchery proportion of 0.7, and the median number of hatchery-produced Chinook salmon that survive and/or are released into San Francisco Bay under COS (16,831,019), the estimated survival rate of juvenile Chinook salmon smolts in San Francisco Bay to the adult stage in the ocean (age 3+) is 0.0189 (Table 2.5.8-3; Appendix L). In addition, using this same information we can estimate that contribution of naturally produced CV Chinook salmon in San Francisco Bay would have been 7,213,294 juvenile smolts.

From this point, it is possible to combine the combined upstream and delta survival effects under the PA compared to COS for all hatchery and naturally produced CV Chinook salmon and project these results in terms of changes in the adult (age 3+) ocean abundance of CV Chinook salmon under the PA compared to COS, including results from winter-run Chinook salmon IOS model runs. Using estimates of ocean abundance from 2001-2018, the percent change in abundance is a 0.21 percent decrease (~950 adult Chinook salmon) at the median value, and a 2.21 percent (~9,700 adults) decrease at the 2.5 percentile and 2.43 percent increase (~12,600 adults) at the 97.5 percentile (Table 2.5.8-3; Appendix L).

Table 2.5.8-3. Abundance of Central Valley Chinook salmon available as prey for Southern Resident killer whales under the COS and PA scenarios and change in abundance between scenarios.

	median	97.5 %ile	2.5 %ile
Natural Chinook smolts in Bay baseline (COS)	7,213,294	7,345,971	7,212,754
Natural Chinook smolts in Bay in PA	7,199,260	7,829,734	6,654,245
Hatchery juvenile Chinook total in Bay COS	16,831,019	19,710,070	16,082,252
Hatchery juvenile Chinook total in Bay PA	16,792,102	19,647,691	16,135,970
Total juvenile Chinook in Bay (COS)	24,044,313	27,056,041	23,295,006
Total juvenile Chinook in Bay (PA)	23,991,362	27,477,426	22,790,215
Bay to ocean adult survival	0.0189	0.0189	0.0189
Ocean Adult Chinook Abundance (COS), not including winter-run	454,052	510,925	439,902
Ocean Adult Chinook Abundance (PA), not including winter-run	453,052	518,882	430,369
Adjustment for winter-run from IOS model			
Winter-run Chinook COS (IOS model) *	3,293	9,345	446
Winter-run Chinook COS to PA (proportional IOS model changes)	0.015	0.501	-0.450
Winter-run Chinook PA (IOS model changes)	3,342	14,024	245
Ocean Adult Chinook Abundance (COS)	457,345	520,270	440,347
Ocean Adult Chinook Abundance (PA)	456,393	532,907	430,615
Change in median number of Adult Chinook in the			
Ocean COS to PA	-951	12,637	-9,733
Percent abundance change in adult Chinook in the			
Ocean from COS to PA	-0.21%	2.43%	-2.21%
Change in Chinook Biomass (pounds) COS to PA**  * The median winter-run Chinook ocean abundance for 2001-2018 v	-		-164,386

^{*} The median winter-run Chinook ocean abundance for 2001-2018 was used as the baseline in COS and proportional changes over the IOS modeling period are applied to that value

# 2.5.8.1.4.11 Limitation of Model Estimates of Productivity Changes under PA Compared to COS

The models used to construct the estimated changes in the overall productivity of CV Chinook salmon described above are limited to evaluating the impacts that are quantifiable within those models. As described above in Section 2.5.8.1.2 *Effects of the Proposed Action on Chinook Salmon Individuals*, there are numerous other stressors on various segments of Chinook salmon populations as a result of the PA that are not quantified or accounted for in these models.

Table 2.5.8-4 lists the models used above in estimating changes in survival and productivity for CV Chinook salmon populations under the PA compared to COS.

^{**} median adult weight of 16.89 pounds

Table 2.5.8-4. List of models used to estimate changes in Central Valley Chinook salmon productivity under the PA compared to COS.

Model or Analytical Method	Passage Impediments/Barriers	Harvest/Angling Impacts	Water Temperature	Water Quality	Flow Conditions	Loss of Riparian Habitat and Instream Cover	Loss of Natural River Morphology and Function	Loss of Floodplain Habitat	Loss of Tidal Marsh Habitat	Spawning Habitat Availability	Physical Habitat Alteration	Invasive Species/Food Web Changes	Entrainment	Predation	Hatchery Effects
DPM					X			X					X	X	
CalSim II					X										
IOS			X		X			X	X	X			X	X	
Salmod			X		X					X					
SacSalMort/ Reclamation Egg Mortality Model			x							Х					
Winter-Run Life Cycle Model		X	X		X	X	Х	х	X	X			X	X	
Salvage Density Model					X							i.	X		

Although not included in the Salmod model, flow modeling shows that flows will drop in September prior to fall-run Chinook salmon spawning, and general the extent of potential dewatering that might occur for fall-run Chinook salmon in the Sacramento River will be reduced in the proposed action compared to current operations (Appendix L). However, this could shift dewatering effects from fall-run to winter-run Chinook salmon depending on how real time operations interact with winter-run Chinook salmon redds (Appendix L).

The survival of juvenile Chinook salmon emigrating out of the Stanislaus River, down the San Joaquin River, and through the Delta is generally approximately 2 percent, although changes in survival between current and future scenarios has not been quantified. March through May flows in the Stanislaus River are slightly lower under the PA scenario, so juvenile emigration survival through the Delta and into San Francisco Bay should be slightly reduced (Section 2.5.6-7; Appendix L).

Under the original PA, Delta pumping would increase under the PA in April and May during the primary outmigration season for fall-run Chinook salmon (Appendix L). Salvage-density analysis assumes changes in salvage (and loss) occur in proportion to the change in amount of water pumped between scenarios. The effects of increased pumping in April and May on winterrun Chinook salmon and spring-run Chinook salmon are described in detail in Section 2.5.6.7.2.1

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("South Delta Salvage and Entrainment"); similar effects are expected for fall-run Chinook salmon during April and May. The projected combined loss at the CVP and SWP in the COS and PA scenarios are summarized in Table 2.5.8-5. Except for late fall-run Chinook salmon in wet years, projected loss is higher under the PA.

While loss is still expected to occur under the final PA, NMFS notes that the revised loss thresholds in the June 14, 2019 PA are expected to limit risks associated with the near-field effects (entrainment into and loss at the export facilities) to levels less than estimated using the Salvage Density Model. The intent of the loss thresholds is to limit loss to levels comparable to loss observed under the COS. However, because the only loss threshold in effect during April-June 15 is for natural steelhead, the revised loss thresholds in the final PA only indirectly provide protections for outmigrating young-of-year fall-run Chinook salmon and CV spring-run Chinook salmon during this period. The final PA includes triggers for review and technical assistance anytime observed loss exceeds average annual historical loss, which provide some assurance that species risks will be conservatively managed. The Salvage Density Model shows the greatest differences in the PA vs. the COS during April and May, when fall-run Chinook salmon are migrating through the Delta, and the revised loss thresholds are expected to provide an incremental level of additional protection relative to the original PA during this period.

Table 2.5.8-5. Projected combined loss at the CVP and SWP for the February 5, 2019, COS and PA scenarios, by Chinook salmon run and water year type. Positive differences in the final column represent increases in projected loss in the PA relative to the COS. Revised loss thresholds in the June 14, 2019 PA may limit Chinook salmon loss to be more comparable with the COS scenario, though there are not specific loss thresholds for fall-run, late fall-run, or CV spring-run Chinook salmon.

Run	Yeartype (Sacramento "40-30-30" Index under ELT Q5 hydrology)	Predicted loss under COS	Predicted loss under PA	Difference in predicted loss (PA- COS)	% Change
	Wet	86,601	130,431	43,830	51%
	Above Normal	32,188	60,387	28,198	88%
Fall-run	Below Normal	18,341	29,905	11,563	63%
	Dry	27,353	51,530	24,177	88%
	Critical	6,966	11,405	4,439	64%
Late fall-run	Wet	357	351	-6	-2%
	Above Normal	312	336	25	8%
	Below Normal	33	38	4	13%
	Dry	178	188	11	6%
	Critical	45	50	4	9%
Spring-run	Wet	42,532	86,606	44,074	104%
	Above Normal	23,057	59,659	36,603	159%
	Below Normal	5,814	11,679	5,865	101%
	Dry	13,885	24,118	10,233	74%
1	Critical	7,628	12,474	4,845	64%
Winter-run	Wet	12,417	13,788	1,371	11%
	Above Normal	6,369	6,805	437	7%
	Below Normal	5,830	6,812	982	17%
	Dry	4,106	5,070	965	23%
Ī	Critical	1,230	1,702	472	38%

This salvage-density analysis estimates loss, but does not estimate that loss as a proportion of all CV fall-run Chinook salmon, so we are unable to determine a population level effect at this time. The loss estimates from the salvage-density analysis are not explicitly factored into the models of changes in Chinook salmon productivity described above. With respect to the Delta Passage Model, salvaged salmon do not enter the interior Delta and are not influenced by the survival relationships described by that model. Delta exports more strongly affect Chinook outmigrating from the San Joaquin River tributaries than those from the Sacramento River side. The increase in pumping would most strongly affect the approximately 2.6 percent of all CV Chinook salmon that come from the San Joaquin side of the Delta, particularly at the CVP facility. The Delta Passage Model was not adapted to the San Joaquin River so there is no assessment in the difference in survival between scenarios for San Joaquin River fall-run Chinook salmon. Ultimately, we assume that salvage rates will increase for CV Chinook salmon, especially for fall-run Chinook salmon populations.

#### 2.5.8.1.4.12 Restoration Activities

Reclamation identified a number of these restoration actions or programs that have been occurring, and which are expected to continue into future. An analysis of any negative and/or beneficial effects to fish and their habitat has been completed for those actions or programs that previously underwent separate ESA section 7 consultations, and are therefore described in the environmental baseline section. For those programs or actions Reclamation identified as linked to the PA, and will continue into the future, we consider any expected continued negative and/or beneficial effects to listed fish and habitat at a broader scale - or "framework-level" only. For any identified new restoration programs or actions that lack sufficient detail to analyze and quantify level of impact at the level of incidental take, the program or action would require a separate section 7 consultation when sufficient details are available. Reclamation has proposed to conduct habitat restoration projects in the Sacramento River, American River, and Stanislaus River through 2030. Projects would occur annually with a goal to complete at least one habitat improvement project on each of these rivers each year. Cumulative habitat creation is proposed as 40-60 acres on the Sacramento River, 40 acres on the American River (based on 4.0 acres/year from among the identified sites), and 50 acres on the Stanislaus River. By 2030, an estimated 15,273 additional Chinook salmon could be available, assuming that habitats are otherwise at carrying capacity and that any new habitat translates directly into more fish (Appendix L). However, water operational factors are not figured into these estimates so these estimates cannot be directly aggregated with the prey estimates above. While the specific level impact of restoration benefits that may be realized is uncertain, we anticipate that the increase in habitat should help to offset impacts to populations from water operational factors and improve conditions for naturally produced Chinook salmon in California's Central Valley.

# 2.5.8.1.5 Summary of Project Effects on Central Valley Chinook Salmon Productivity

Proposed action-related stressors are expected to reduce the fitness, survival, and abundance of Chinook salmon individuals from all CV Chinook salmon populations during all life stages, through direct impacts as well as reduced quality and quantity of available habitat within the action area. While there are numerous adverse and potentially beneficial effects associated with the PA for Chinook salmon, impacts associated with water temperature management and Delta export operations are especially acute for all CV Chinook salmon populations. For ESA-listed winter-run and CV spring-run Chinook salmon ESUs, we have concluded that the PA is likely to increase the risk of extinction for the populations due to reduced viability across several VSP parameters. For non-ESA-listed species, we conclude that continued water operations will likely continue to lead to diminished productivity of these populations, including reducing the abundance of natural-origin fall- and late fall-run Chinook salmon by significant amounts that can vary widely depending in part on environmental variability. There is no estimate in terms of the overall reduction in the number of adult Chinook salmon that may be in the ocean as a result of water operations, but we note the ongoing apparent decline in the relative abundance of Chinook salmon over time for most Chinook salmon ESUs in the Central Valley, especially the dominant fall-run Chinook salmon populations, that has been occurring in concert with ongoing water operations along with other significant factors described in Section 2.4 Environmental Baseline.

With respect to COS, available models suggest the PA is expected to lead to an additional increased reduction in productivity of CV Chinook salmon due to reduced survival of juveniles

in upstream areas and through the Delta into San Francisco Bay during the majority of years, which equates to an overall additional reduction in the number of Chinook salmon that survive to the ocean in subsequent years. In particular, results suggest that fall-run, late fall-run, and CV spring-run Chinook salmon populations will experience decreased productivity on average under the PA compared to COS, with fall-run Chinook salmon representing the bulk of CV Chinook salmon productivity. There are conflicting model results about the expected impact of the PA on the productivity of winter-run Chinook salmon, but winter-run Chinook salmon make up a very small percentage of the total amount of CV Chinook salmon productivity. The reductions in Chinook salmon productivity that are estimated by the models through various portions of their life-stage, and in-total through the Central Valley system to the ocean, are not necessarily large for most years (overall <1 percent median estimate), including variable impacts on natural and hatchery production released into the Central Valley. Expectations are that there will be several hundred less adult CV Chinook salmon on average in the ocean under the PA compared to what might be available under COS. While the available models do incorporate some of the key stressors identified for CV Chinook salmon populations, some stressors are not readily quantifiable and/or cannot be incorporated into these models, and some portions of the Central Valley system could not be evaluated given the available data (all stressors for ESA-listed Chinook salmon summarized in Tables 2.8.2.1 and 2.8.3.1). As a result, we conclude it is likely that the models have not fully captured all of the potential difference between CV Chinook salmon productivity. As discussed above, Reclamation identified a number of these restoration actions or programs that have been occurring, and which are expected to continue into future, in addition to proposing restoration actions linked to the PA. These ongoing and new restoration actions are expected to improve Chinook salmon habitat.

#### Effect of Reduced Prey for SRKW

The information described previously in this Opinion suggests that the health of individual animals and the overall population dynamics of SRKW are related to the abundance of Chinook salmon available as prey throughout the range of SRKW. Reductions in availability of preferred prey (Chinook salmon) would be expected to influence the behavior and potentially affect the fitness of individual SRKW, and may affect the survival and reproductive success of SRKW. As described in the Section 2.2.9 Rangewide Status of SRKW and Appendix B, and the Section 2.4.7.4 Factors Affecting the Prey of SRKW in the Action Area, during the winter and spring, SRKW (particularly members of K and L pod) are likely to spend at least some time in coastal waters where they would be affected by reductions in CV Chinook salmon (especially fall-run Chinook salmon) abundance due to the proposed action. As described in Factors Affecting the Prey of SRKW in the Action Area section (Section 2.4.7.4), SRKW (particularly members of K and L pod) are linked to consumption of Chinook salmon from California based on the contaminant signatures discussed above. As described in Factors Affecting the Prey of SRKW in the Action Area section (Section 2.4.7.4), CV Chinook salmon, especially fall-run Chinook salmon, can constitute a sizeable proportion of the total abundance of Chinook salmon that is available throughout the coastal range of SRKW (~ 20 percent on average, but varying substantially between ~10 and 30 percent during any given year). As described in the Factors Affecting the Prey of SRKW in the Action Area section (Section 2.4.7.4), CV Chinook salmon become an increasingly significant portion of prey source during any southerly movements of SRKW along the coast of Oregon and California that may occur during the winter and spring, and CV fall-run Chinook salmon can be expected to constitute at least 25 percent local

abundance in many places throughout this area at any time (Bellinger et al. 2015), and are expected to constitute well over 50 percent of local abundance of Chinook salmon in some areas off California when SRKW are present there (Shelton et al. 2019).

With respect to short-term effects, SRKW could abandon particular areas where prey resources are limited and/or have been reduced in search of more abundant prey or expend substantial effort to find prey resources in response to a decrease in the amount of available Chinook salmon due to the proposed action. These changes in behavior can result in increased energy demands for foraging individuals as well as reductions in overall energy intake, increasing the risks of being unable to acquire adequate energy and nutrients from available prey resources (i.e., nutritional stress). SRKW are known to consume other species of fish, including other salmon, but the relative energetic value of these species is substantially less than that of Chinook salmon (i.e., Chinook salmon are larger and thus have more energy value). Reduced availability of Chinook salmon would likely increase predation activity on other species (and energy expenditures) and/or reduce energy intake.

With respect to longer-term effects, numerous studies have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) leading to reduced body size and condition and lower reproductive and survival rates for adults (e.g., Daan et al. 1996, Gamel et al. 2005) and juveniles (e.g., Trites and Donnelly 2003, Noren et al. 2009). In the absence of sufficient food supply, adult females may not successfully become pregnant or give birth and juveniles may grow more slowly. Any individual may lose vitality, succumb to disease or other factors as a result of decreased fitness, and subsequently die or not contribute effectively to future productivity of offspring necessary to avoid extinction and promote recovery of a population. Ultimately, the effect of reduced prey for SRKW could lead to behavior changes and nutritional stress over the short term that could negatively affect the animal's growth, health, reproductive success, and/or ability to survive over the long term.

#### 2.5.8.1.5.1 Project-Related Impacts of Reduced Prey Base for SRKW

Based on the analyses of expected effects of the PA to CV Chinook salmon populations, reductions in the survival and productivity of CV Chinook salmon populations (especially fallrun Chinook salmon) are expected to occur throughout the proposed action, and the greatest effects will occur during the drier water years when effects of the proposed action are most pronounced. These reductions would decrease the abundance of Chinook salmon populations in the ocean and the availability of these Chinook salmon populations as prey for SRKW in the southern portion of their coastal range. The reduced abundance of prey could be detected by all members of K and L pod during foraging on a reduced prey field, leading to increased expenditures of energy during foraging. The exposure of members of J pod to reduced Chinook salmon abundance in coastal waters is not as clear based on the available data regarding their distributions and contaminant signatures as described in Section 2.4.7.4 Factors Affecting the Prev of SRKW in the Action Area, but available information suggest their exposure may be much more limited or nonexistent. The expected consequences of biologically significant reductions in the abundance of preferred prey for these SRKW are reductions in the fitness of individuals because impaired foraging behavior and increased energy expended to find sufficient prey and nutritional stress, which can diminish health, lower growth rates, lower reproductive rates and increase mortality rates. Based on the general relative analyses that have been described in

Section 2.5.8.1.2 Effects of the Proposed Action on Chinook Salmon Individuals, all members of K and L pod are expected to be adversely affected, or "harmed," ²⁷ through the increased risk of impaired foraging due to decreased Chinook salmon abundance in the ocean resulting from effects of the proposed action.

Based on the analyses of expected effects of the proposed action to CV Chinook salmon, we generally cannot fully quantify the overall impacts due to the operational effects of the PA on SRKW in terms of the absolute reduction in Chinook salmon in the ocean that is attributable to the PA. As described above, the productivity of CV Chinook salmon populations as measured by escapement has been decreasing over the last 20 years. This is especially true for the dominant fall-run Chinook salmon populations, where escapement during most of the last 10 years has been substantially lower than previous time periods. Previous analysis of water operations suggested that the natural production of fall-run and late fall-run Chinook salmon is about ~10 percent less on average than it could be under other operation scenarios that aim to maximize Chinook salmon production, although this could vary widely and include much higher productivity reductions under certain environmental conditions. Currently, hatchery fall-run Chinook salmon production represents a significant portion of the overall CV Chinook salmon productivity (~70 percent), and significant effort is required to implement hatchery release programs designed to overcome low survival rates for juveniles through a large portion of the Central Valley system resulting from habitat conditions and stress created in part by ongoing components of the PA.

With respect to the PA compared to COS, our expectations are that the productivity of most CV Chinook salmon populations, especially fall-run Chinook salmon, and the total Chinook salmon productivity of the entire system, will experience even further reduction and limitations on average/during the majority of years under the PA. Although the difference between COS and PA overall is estimated to be relatively small (<1 percent), these results may not be representative of the total extent of relative changes in impacts under the PA. What is more certain is that under the PA is that fewer Chinook salmon would be expected survive to the ocean than was has been occurring under COS. Additional stressors that could not be quantified suggest the relative impact of the PA compared to the COS could be larger than model estimates generated.

In general, our overall qualitative assessment indicates that the conditions for CV Chinook salmon as a result of water project operations will result in continued reductions and limitations in juvenile Chinook salmon survival and fitness that are expected to reduce the abundance of CV Chinook salmon populations in the ocean. In particular, decreased and limited abundances resulting from the proposed action are expected for CV fall-run Chinook salmon, which constitute a significant portion of all Chinook salmon adults in the ocean in the action area, and generally throughout the ocean range of SRKW. In addition, we anticipate that under the PA there will commonly be years when at least several hundreds or thousands less adult Chinook salmon could be available as prey for SRKW in the action area compared to COS, especially during years when environmental conditions may provide the most potential stress on juvenile CV Chinook salmon broods when their survival on the way to the ocean would already be

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²⁷ As harm is defined in ESA implementing regulations (50 CFR § 222.102), we associate changes in foraging behavior and increased risk of nutritional stress as causing injury to Southern Residents "by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering"; specifically, in this case, feeding.

heavily impacted. Even if the reduction in productivity under the PA compared to COS is not large, the overall trend toward increasing the impact of water operations on CV Chinook salmon productivity will exacerbate conditions that are challenging for Chinook salmon survival to the ocean. For ESA-listed CV Chinook salmon species, the PA is expected to increase the risk of extinction for these ESUs, potentially placing even further limitations on the future productivity of the Central Valley system and the abundance of Chinook salmon in the ocean as prey for SRKW.

### 2.5.8.1.5.2 Consequences of Reduced Prey Base for SRKW

Based on the analysis above, NMFS expects that the proposed action will generally reduce the productivity and abundance of CV Chinook salmon (especially fall-run) available in the ocean for SRKW to forage, especially during time periods when environmental conditions are creating additional stress on the productivity and survival of CV Chinook salmon. Reduced abundance, in a range of magnitudes dependent upon other environmental factors, will continue to extend throughout the duration of the PA, which is indefinite. These reductions in available prey are most likely to be detected by all members of K and L pod, during foraging on a reduced prey field. The result is that SRKW, especially for K and L pod whales, are expected to periodically face conditions where individuals present in the action area are required to spend more time foraging, which increases energy expenditures and the potential for nutritional stress, which can negatively affect the animal's growth, body condition, and health.

#### 2.5.8.1.5.3 Short-term Effects

As described in Section 2.4.7.4 Factors Affecting the Prey of SRKW in the Action Area, CV Chinook salmon (especially fall-run) are expected to constitute a significant component of the diet of SRKW in coastal waters within the action area where they overlap. In the short term, SRKW are expected to detect and respond to reduced CV Chinook salmon abundance and a reduced prey field during foraging, likely resulting in SRKW searching for other Chinook salmon and more abundant prey fields, either within the action area and/or other parts of their range. While Chinook salmon are expected to be the preferred prey with high nutritional value, SRKW are capable of taking advantage of other prey sources to supplement their nutritional needs and are assumed to do so in the immediate absence of sufficient Chinook salmon resources. Based on the distribution of CV Chinook salmon described in Section 2.4.7.4 Factors Affecting the Prev of SRKW in the Action Area, any nutritional and energetic stress impacts caused by the proposed action are most likely to occur in the more southerly range of SRKW. Based on research and the known distribution of SRKW described in Section 2.2.9 Rangewide Status of SRKW and Appendix B, and Section 2.4.7.4 Factors Affecting the Prey of SRKW in the Action Area, we conclude that while SRKW are known to occasionally use the southerly end of their range where CV Chinook salmon are a predominant prey source, it is also likely that this population may limit or avoid use of this area altogether during some years as a result of limited prey availability.

The harm created by the PA in the short term is the anticipated changes in the foraging behavior of SRKW in the action area and increased risks of nutritional stress that are perpetuated, and potentially exacerbated, by the PA. Ford and Ellis (2006) report that SRKW engage in prey sharing about 76 percent of the time during foraging activities. Prey sharing presumably could distribute more evenly any short-term effects of prey limitation across individuals of the

population than would otherwise be the case (*i.e.*, if the most successful foragers did not share with other individuals). We also recognize the ability of SRKW to take action to search out other areas with more abundant Chinook salmon prey fields or take advantage of other prey sources to supplement their nutritional needs in the immediate absence of sufficient Chinook salmon resources and the likelihood that SRKW may avoid the southern end of their range in some years (where CV Chinook salmon are most important as a prey source). As a result, we conclude it is likely that the relative magnitude of short-term adverse effects resulting from the behavioral changes and nutritional stress that may occur in response to reduced abundance of CV Chinook salmon prey in the ocean available to SRKW in the ocean at any one particular time during of the proposed action would likely be limited in extent and moderated to some degree by the factors discussed above. Consequently, we do not anticipate severe short-term adverse effects such as immediate mortality or reproductive incapacitation directly as a result of short term exposure to the effects of the PA.

# **Long-term Effects**

While the overall absolute impact of the PA on the survival and abundance of CV Chinook salmon is not quantified, there is information that suggests the effects of the PA will likely exacerbate the existing reductions and limitations on CV Chinook salmon productivity as a result of the PA, especially for the larger populations of Chinook salmon (fall-run Chinook salmon in particular) that contribute a substantial amount of overall Chinook salmon production and abundance in the ocean range of SRKW, and are increasingly significant in large stretches of that range. Over the long term, we expect the extent of this impact to be persistent over time, and increasingly acute during years when environmental conditions are increasingly challenging for Chinook salmon survival throughout the Central Valley system, further amplifying the significance of the reductions in Chinook salmon productive expected to occur as a result of the PA. The future projections of climate-related impacts and conditions that present challenges for CV Chinook salmon are described in Section 2.4 (Environmental Baseline), which suggests that these challenges are likely to increase and/or emerge on a more frequent basis moving forward in the coming decades. In addition to the immediate reduction of CV Chinook salmon in the ocean as a result of diminished survival directly as a result of the PA, we conclude that the increased extinction risk for some CV Chinook salmon populations created by the PA potentially limits the long term future productivity and diversity of prey sources for SRKW. As a result, over time, we expect the effect of reduced Chinook salmon abundance and productivity will likely not relent under the PA, but to continue and escalate as the productive capacity of the Central Valley system is diminished as some Chinook salmon populations head to extinction.

Although SRKW may have the ability to take action to search out other areas with more abundant Chinook salmon prey fields or take advantage of other prey sources to supplement their nutritional needs in the immediate absence of sufficient Chinook salmon resources, the significance of the contribution of CV Chinook salmon to the overall total available prey resources within the action area and total abundance of Chinook available in the ocean for SRKW across their range on an annual basis suggests that over the course of a given season, and persistently year after year, SRKW may have to consistently and persistently expend this additional energy to overcome limitations in available prey and any nutritional stress that is created by effects of the PA. Recently, as described in Section 2.2.9 Rangewide Status of SRKW and Appendix B, a number of individuals from the SRKW population have been showing signs of poor body condition, nutritional stress and overall diminished health. Based on the analysis, it

is likely that conditions under the PA where SRKW are exposed to and affected by reductions and limitations in the abundance of Chinook salmon available as prey as a result of the PA will increase over time. As a whole, as described in Section 2.2.9 Rangewide Status of SRKW and Appendix B, the population has recently been experiencing low fecundity rates and projections are that the population will decrease in the future as a result. The effect of perpetual and/or additional nutritional stress over time for individual SRKW that are already experiencing and showing signs of nutritional stress is an additional reduction in fitness that increases the probability of reduced survival and/or reproductive success for at least some members of the SRKW population that are already compromised, or potentially contributing to diminishing the fitness of individuals to a compromised state over time where reduced survival and/or reproductive effects become increasingly likely to occur.

# 2.5.8.2 Supplemental Analysis of June 14, 2019, Final PA

During consultation for this Opinion, discussions between NMFS and Reclamation resulted in revisions to the PA that were not captured in the February 5, 2019, BA that was used for the majority of the analysis in this Opinion. Also during the consultation for this Opinion, the Sacramento River Settlement Contractors (SRSC) drafted for adoption a resolution for activities involving recovery projects, actions related to annual operations, and engagement in ongoing science partnership. It was not possible to include these revisions in any modeling due to the White House memorandum that mandated issuance of final biological opinions within 135 days of January 31, 2019 (June 17, 2019, and subsequently extended to July 1, 2019), and limitations in the capability to quantitatively assess their influence on PA effects. The effects description above (Section 2.5.8.1.2-2.5.8.1.4) was based on the modeling associated with the February 5, 2019 PA (Appendix A1, the original PA) and associated modeling that NMFS requested. The following subsection provides a supplemental effects analysis to assess the effects of the June 14, 2019 PA revisions reflected in the final PA (Appendix A3), including a discussion of whether and how the PA revisions modify the effects analyzed above.

# 2.5.8.2.1 Upstream Productivity

Revisions to the Cold Water Pool Management section of the final PA include the addition of Section 4.10.1.3.3 Upper Sacramento Performance Metrics, described in more detail in Section 2.5.2.6.1 Revisions to the PA Relevant to the Shasta/Upper Sacramento Division. The objective of these performance metrics is to ensure that the performance falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of the PA. This addition to the Cold Water Pool Management section contributes to increasing the certainty that the central tendency of the analyzed results is what the species will experience when these operations are implemented. That is, the analysis characterized exposure and risk based on the central statistics of modeled TDM for each Tier type and the long-term projected likelihood of occurrence of each year type. However, the TDM results included a broad range for each Tier due to the variability of conditions included in each Tier type. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which is based on the central tendency to capture the most likely conditions – to be a more accurate characterization of projected and expected operations. The results described in Section 2.5.8.1.4 Changes in Chinook Salmon Productivity under the PA compared to COS do not change quantitatively due to the revisions included in the final PA, as

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this commitment to assess cold water management does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

The final PA includes a number of commitments for funding and improvements at Livingston Stone National Fish Hatchery, described in more detail in Section 2.5.2.6.1 *Revisions to the PA Relevant to the Shasta/Upper Sacramento Division*. Most of these actions are expected to benefit winter-run Chinook salmon to some degree, but it is unclear if any benefit would extend to other Chinook salmon populations, or if these actions could influence the overall analysis of Chinook salmon productivity given their focus on a small part of the overall abundance of Chinook salmon.

The final PA includes revisions to the Governance section of the PA that include the addition of Section 4.12.5 Drought and Dry Year Actions to develop a toolkit of actions to be taken in drought conditions, and a process by which early warnings of drought conditions may allow for clear and swift development of a drought contingency plan. Compared to the previous analysis, the addition of the drought and dry year actions decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that any actions taken in this instance would increase the likelihood that resulting mortality values would be minimized to the extent possible. With this change, we consider our previous analysis of the modeled outcomes of temperature management to still apply as a conservative characterization of projected and expected operations. The results described in Section 2.5.8.1.4 Changes in Chinook Salmon Productivity under the PA compared to COS could slightly over-represent a high mortality event that could be prevented by this Drought and Dry Year Action; however, the results of the modeling would not notably change the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

The final PA includes revisions to the Governance section of the PA that include the addition of Section 4.12.6 Chartering of Independent Panels and Section 4.12.7 Four-Year Reviews to charter reviews either at set dates or as triggered. The review topics are expected to include the Upper Sacramento Performance Metrics and associated topics in that section. While the reviews will be greatly informative in increasing the understanding of effects of temperature conditions and operational decisions on species response, they are post-hoc evaluations that alone do not afford additional protections to the species or alter the quantitative analysis already completed based on the modeling results. The results described in Section 2.5.8.1.4 *Changes in Chinook Salmon Productivity under the PA compared to COS* will not change quantitatively, as this commitment to assessing the performance of the PA does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

The actions and commitments within the draft SRSC Resolution, described in more detail in Section 2.5.2.6.1 *Revisions to the PA Relevant to the Shasta/Upper Sacramento Division*, are expected to benefit Chinook salmon populations. NMFS expects that any actions taken in response to Tier 3/Tier 4 conditions would increase the likelihood that resulting mortality values would be minimized to the extent practicable, particularly for winter-run Chinook salmon. Additionally, delayed diversions for rice decomposition during the fall months could provide increased reliability that target flows would be met and reducing the effects of flow fluctuations.

The continuation of the recovery actions by the SRSC is expected to result in long-term benefits for CV Chinook salmon populations, including fall-run Chinook salmon. The commitment to establish and implementation of the Mainstern Sacramento River Integrated Water and Fish Science and Monitoring Partnership is expected to improve the science that is used to protect and support the recovery of CV Chinook salmon populations, including fall-run Chinook salmon. However, it is not possible to describe their benefits more specifically or quantitatively at this time based due to limited information on their effectiveness and/or uncertainty on how these actions will ultimately be incorporated into future project operations.

On June 19, 2019, USFWS sent a letter to NMFS providing an update on efforts that USFWS has been engaged in, largely in partnership with BOR, regarding CNFH and LSNFH and their contribution to the management and restoration of CV Chinook salmon. With respect to improving the overall productivity of Chinook salmon, these efforts include design of a fish trapping and sorting facility at CNFH to minimize handling and migration delay of listed species during CNFH's fall-run Chinook salmon spawning operations, and to allow for passage, monitoring, and management of fish passage during times when spawning operations are not taking place. Design is underway, but funding to complete construction has not yet been secured. Notable efforts also include studies of alternative release strategies for CNFH produced fall-run Chinook salmon that have potential for increasing juvenile survival to the ocean and adult returns to the Sacramento River without unacceptable levels of straying. To date, USFWS has completed one year of a three-year study, and is close to securing funding to complete the project. At this time results are not yet available to inform any long term alternative release strategies moving forward, although we do expect any successful strategies implemented as a result of these studies to benefit CV Chinook salmon populations in the future.

### 2.5.8.2.2 Delta Productivity

The revised PA includes revisions to the OMR Management component of the PA that are described in detail in Section 2.5.5.11.1 *Revisions to OMR Management*. The cumulative and single-year loss thresholds for CV salmonids proposed were developed to limit loss for key (and reliably measurable) populations to loss rates observed under implementation of the NMFS 2009 Opinion. The intent of these PA revisions was to limit direct loss at the south Delta export facilities as a way to limit some of the higher-magnitude effects under the original PA – specifically, effects associated with DCC operations, OMR Storm Flexibility, and increased exports in April and May. The concept was that, rather than use the hydrodynamic metric of OMR to manage species risks, we could use a metric of historical loss rates to keep risks comparable to risks under the NMFS 2009 Opinion. NMFS concludes that this approach is a reasonable way to limit risks associated with the near-field effects (entrainment into and loss at) the export facilities.

While there are some uncertainties in how this new approach will be implemented, the final PA includes triggers for review and technical assistance anytime observed loss exceeds average annual historical loss, which provide some assurance that species risks will be conservatively managed. While loss is still expected to occur under the final PA, NMFS notes that the loss thresholds are expected to limit loss to levels less than estimated using the Salvage Density Model results described in Section 2.5.5.8.3.1, and to levels comparable to loss observed under the COS. The Salvage Density Model showed the greatest differences in the PA vs. the COS during April and May, and NMFS expects that the benefits of the revised loss thresholds (relative

to the original PA) will be greatest during this April-May period during outmigration of CCV steelhead (particularly from the San Joaquin basin) and young-of-year CV fall-run and spring-run Chinook salmon.

It is less certain whether this approach will fully limit risks associated with the far-field effects (potential disruptions to migration rate or route) of the export facilities. Because NMFS assumes that far-field effects are correlated with exports (both footprint and magnitude of hydrodynamic effect greater at higher exports), limiting near-field effects to historical rates could be assumed to limit far-field effects to historic rates. However, it is likely that OMR (and associated Delta hydrodynamics) may still be more negative under the final PA than observed under the COS, especially in April and May. If OMR (and associated Delta hydrodynamics) is more negative under the final PA than observed under the COS, far-field effects under the final PA are expected to be intermediate between the COS and the original PA.

The revised PA also clarified that DCC openings in December through January would be limited to occasions when drought conditions are observed and gate opening will help to address water quality concerns, which is expected to occur less than 10 percent of the time. The final PA also includes a new commitment to reduce combined CVP/SWP exports to health and safety levels (NMFS assumes that this is 1,500 cfs) during any DCC gate opening in December or January. This may have some benefit for juvenile winter-run Chinook salmon during their migration in December and January, but may not offer much additional protection for other Chinook salmon beyond the anticipated effects that were previously analyzed.

# 2.5.9 LifeCycle Models

Life cycle models of winter-run Chinook salmon were used to analyze population abundance, cohort replacement rate, habitat use distribution, and juvenile survival differences between the COS and PA. These models characterize the dynamics of multiple lifestages, including eggs, fry, smolts, juveniles in the ocean, and mature adults in the spawning grounds. The two life cycle models considered in this opinion are the Interactive Object-Oriented Simulation (IOS) Model, the results for which were provided by Reclamation (as supplemental ROC on LTO BA modeling information), and the Southwest Fisheries Science Center's Winter-run Chinook Life Cycle Model (WRLCM). Both the IOS model and the WRLCM provide a more holistic evaluation in their examination of the effects of the action because both models consider the collective effects of disparate action components across the entire life-cycle. And while it is acknowledged that the underlying modeling (CalSimII and HEC-5Q temperature modeling) for both the IOS model and WRLCM does not capture or reflect the entirety of conditions associated with the COS and PA, the IOS model and WRLCM are considered the best available tools for assessing the effect of those conditions on winter-run Chinook salmon.

Given the unique set of results provided by the life cycle models, they are presented here instead of being integrated into, and possibly attributed to, an individual PA component. The results affect the population-level attributes of abundance, productivity, and population trend, rather than just an individual's response described as a relative change in fitness. The analysis presented in this section is comparative in nature and incorporates uncertainties in PA and COS modeling discussed in other effects sections. The comparative analysis is useful in terms of understanding the overall direction of modeled effects and assessing predicted trends on population structure and viability. However, as discussed in Section 2.1 Analytical Approach,

this comparative analysis should not be conflated with an analysis of the full effects of proposed project operations on species. Section 2.8 Integration and Synthesis discusses how NMFS considers the life cycle model results, in addition to other information, in evaluating the operational effects of the PA to species in aggregate with the effects of components of the baseline.

### 2.5.9.1 Interactive Object-Oriented Simulation (IOS) Model Structure

The IOS Model is composed of six model stages defined by a specific spatiotemporal context and are arranged sequentially to account for the entire life cycle of winter-run Chinook salmon, from eggs to returning spawners. In sequential order, the IOS Model stages are listed below.

- Spawning, which models the number and temporal distribution of eggs deposited in the gravel at the spawning grounds in the upper Sacramento River between Red Bluff Diversion Dam and Keswick Dam.
- Early Development, which models the effect of temperature on maturation timing and mortality of eggs at the spawning grounds.
- Fry Rearing, which models the relationship between temperature and mortality of fry during the river rearing period in the upper Sacramento River between Red Bluff Diversion Dam and Keswick Dam.
- River Migration, which estimates mortality of migrating smolts in the Sacramento River between the spawning and rearing grounds and the Delta.
- Delta Passage, which models the effect of flow, route selection, and water exports on the survival of smolts migrating through the Delta to San Francisco Bay.
- Ocean Survival, which estimates the effect of natural mortality and ocean harvest to predict survival and spawning returns by age.

#### 2.5.9.1.1 IOS Model Results

For the first four years of the 82-year simulation period, the starting population of spawning adults for both scenarios is 5,000, of which 3,087.5 are female. In the fifth year, the number of female spawning adults is determined by the model's probabilistic simulation of survival to this life-stage. The model assumes all winter-run Chinook salmon entering the Delta are smolts and that there is no flow- or temperature-related mortality for the river migration (RBDD to Freeport); a mean survival for this stage of 23.5 percent is applied with a standard error of 1.7 percent. Once in the Delta, the survival of smolts is characterized by the Delta Passage Model (DPM) component in which flow, route selection, and water exports determine survival. In IOS, only timing into the Delta is altered from the standalone DPM as spawning events and temperature determine migration towards the Delta.

IOS results show that egg survival is generally very high in most water year types but decreases substantially in critical years. Results for the two scenarios were similar, with median egg survival of 0.99 for both the COS and the PA (Figure 2.5.9-1).

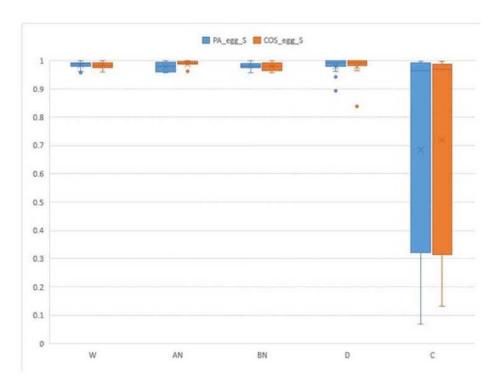


Figure 2.5.9-1. Box plots of annual egg survival for the COS and the PA for winter-run Chinook salmon estimated by the IOS Model by water year type. The x-axis is water year type (Wet, Above Normal, Below Normal, Dry and Critically Dry) and the y-axis is the proportion of egg survival. Note the results are intended to be used in a manner that compares different scenarios.

Likewise, fry survival from Keswick Dam to Red Bluff Diversion Dam is temperature dependent and was very similar for the two scenarios with median fry survival for COS at 0.94 and for the PA at 0.95 (Figure 2.5.9-2).

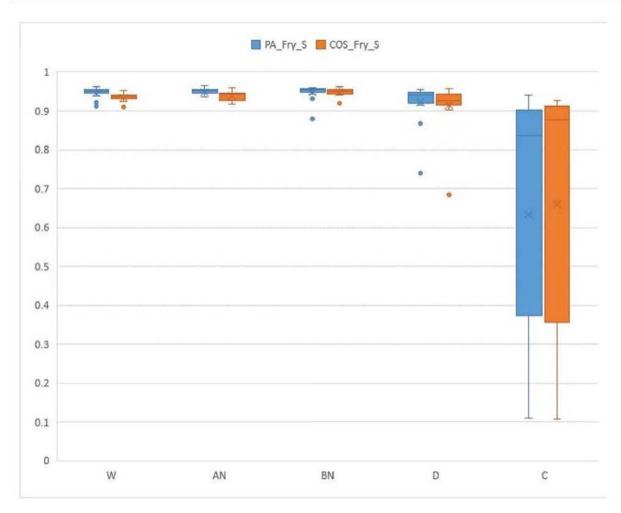


Figure 2.5.9-2. Box plots of annual fry survival for winter-run Chinook salmon from Keswick Dam to Red Bluff Diversion Dam estimated by the IOS Model between the COS and the PA separated by water year type. Here the x-axis is water year type (Wet, Above Normal, Below Normal, Dry and Critically Dry) and the y-axis is the proportion of fry survival. Note the results are intended to be used in a manner that compares different scenarios.

# 2.5.9.1.2 IOS Through-Delta Survival (From Freeport to Chipps Island) Results

Across all years, the IOS model's median predicted through-Delta survival was 0.41 for the COS and 0.42 for the PA (Figure 2.5.9-3).

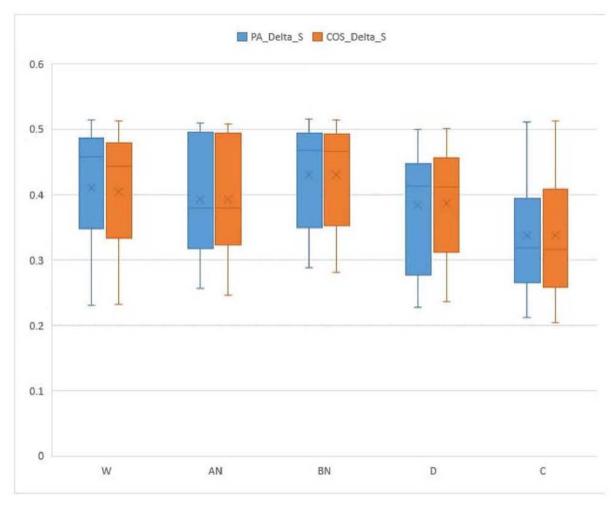


Figure 2.5.9-3. Box plots of annual through-Delta survival for the COS and PA for winter-run Chinook salmon estimated by the IOS Model by water year type. The x-axis is water year type (Wet, Above Normal, Below Normal, Dry, and Critically Dry) and the y-axis is the proportion of juvenile survival through the Delta. Note the results are intended to be used in a manner that compares different scenarios.

# 2.5.9.1.3 IOS Escapement Results

In the IOS model, the probability of survival in the ocean is almost identical for both the PA and COS. The model predicts COS median adult escapement at 3,864 and PA median escapement of 3,909, a population difference of 1.2 percent (Figure 2.5.9-4). In other words, the model predicts a 1.2 percent increase of adult spawners for the PA.

Throughout the life cycle of winter-run Chinook salmon, the IOS model identifies very little difference in results between the COS and the PA. Based on the IOS model, fry survival is the stage most affected by the PA, with an increase of 1.2 percent. IOS results show survival probabilities are similar for both scenarios for all stages, attributing the 1.2 percent increase in escapement to the increased fry survival for the PA. The differences in escapement based on

water year type is not a reflection of hydrologic conditions for the outmigrating juveniles; instead, it is a classification of hydrology for the time when adults returned to spawning grounds.

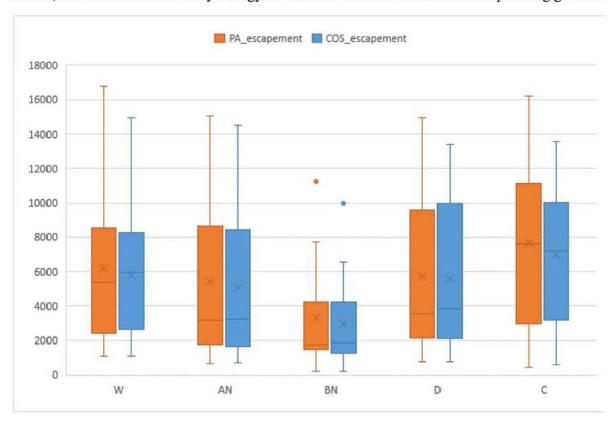


Figure 2.5.9-4. Box plots of annual escapement for the COS and the PA for winter-run Chinook salmon estimated by the IOS Model by water year type. The x-axis is water year type (Wet, Above Normal, Below Normal, Dry, and Critically Dry) and the y-axis is the number of returning adults. Note the results are intended to be used in a manner that compares different scenarios.

#### 2.5.9.2 Sacramento River Winter-run Chinook Salmon Life Cycle Model

A state-space life-cycle model for winter-run Chinook salmon in the Sacramento River (WRLCM) developed by the Southwest Fisheries Science Center was used to analyze differences between the COS and PA. The model has multiple stages, including eggs, fry, smolts, juveniles in the ocean, and mature adults in the spawning grounds. The model is spatially explicit and includes density-dependent movement among habitats during the fry rearing stage. It also incorporates survival from the habitat of smoltification to Chipps Island by applying equations from analysis of reach specific survival in the Delta (Newman 2003). The model operates at a monthly time step in the freshwater stages and at an annual time step in the ocean stages. Parameter estimates for the model were obtained from external analyses, expert opinion, and estimation by statistical fitting to observed data. The observed data included winter-run Chinook salmon natural origin escapement, juvenile abundance estimates at Red Bluff Diversion Dam, and juvenile abundance estimates at Chipps Island. To evaluate alternative management actions,

1,000 Monte Carlo parameter sets were run that incorporated parameter uncertainty, process noise, and parameter correlation.

For survival in the Delta, the WRLCM uses Newman (2003) survival results, which are based on a statistical model and environmental covariates that occurred over the time frame 1979-1995. We also note that the Newman model was developed using juvenile fall-run Chinook salmon reared in hatcheries and released in April and May, which is later than the peak outmigration for winter-run Chinook salmon. While there are more recent evaluations of survival through the Delta, these approaches have yet not been incorporated into the development of the WRLCM and were therefore not available at the time of the evaluations for this Opinion. NMFS acknowledges that a level of uncertainty is introduced by using the older information of Newman (2003), and consider this when evaluating the multiple lines of evidence of the WRLCM and other analytical tools.

The COS and the PA were run for each of the 1,000 parameter sets. It is important to note that the COS and PA should be evaluated in a relative sense using the WRLCM, because relative comparisons are more robust than the absolute predictions from the WRLCM. Moreover, it would be incorrect to equate outputs of the model as equating to actual numbers of fish in the Sacramento River. This perspective is adopted for several reasons: 1) the underlying hydrology of the COS and the PA are based on CalSimII model outputs that are a combination of historical hydrology and future expected hydrological conditions, but do not represent actual historic or future hydrology; 2) the WRLCM model and the models used to provide input to the WRLCM that use the CalSimII results [HEC-RAS, DSM2, and Newman (2003)] require assumptions that would all need to be true; and 3) the WRLCM was not calibrated to produce forecasts of actual abundances. As a result, the WRLCM should be viewed as a tool that can provide guidance on the relative performance of the two sets of operations, and the percent difference (i.e., (PA – COS)/COS * 100 percent) was computed for each of the 1,000 model runs.

A detailed description of the model methods and assumptions, as well as all the scenario results, are contained in the Appendix H of this Opinion.

The model was applied in a scenario that compared the PA to the COS using an initial abundance of 10,000 spawning adults as a representative population of winter-run Chinook salmon. This initial abundance is not meant to reflect current, historical, or projected population trends, but instead is used to seed the model. The standard hydrology used in this evaluation represents the 82-year historical CalSimII record from 1922 to 2002. However, prior to 1926, the WRLCM is initializing; results from these years may disproportionately reflect the initial conditions. To control for this potential artificial skew in results, only annual percent differences from the 1926 abundance value (which may differ slightly between the PA and the COS due to the initialization period) and afterward are used to calculate the abundance and cohort replacement rate (CRR) metrics.

#### 2.5.9.2.1 Results of the Scenario Evaluation

Overall, the WRLCM results indicate higher abundances and lower CRR for the COS relative to the PA. Mean abundance is 3.05 percent less for the PA relative to COS through the modeled time series (Figure 2.5.9-5). The probability that average abundance for the PA would be greater than average abundance for the COS in the 82-year time series is approximately 0.03. That is, of the 1,000 paired runs of the COS and PA, there were 30 in which the average modeled

abundance for the PA was greater than the average modeled abundance for the COS, leading to a probability of 0.03.

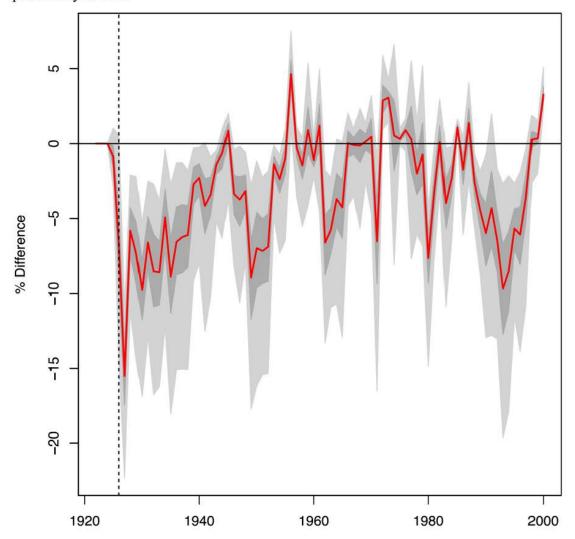


Figure 2.5.9-5. Difference in abundance ((PA – COS)/COS X 100 percent) for 1,000 paired runs of the WRLCM incorporating parameter uncertainty and ocean variability. Results show median (red line), 50th percentile interval (dark grey) and 95th percent interval (light gray).

The CRR is a key metric to understand population dynamics, since it characterizes the ability of a population to replace itself. In the model runs, estimates of the difference in CRR for 1,000 paired runs of the WRLCM indicate that there is a 0.993 probability that CRR would be higher for the PA than the COS over the 82-year model period. There is, therefore, a consistent difference over the model period. However, density dependence in the spawning stages will cause the CRR to decrease for situations with higher spawner abundance. In the WRLCM the spawner density-dependence relationship is a Beverton-Holt function where density-dependent effects begin to occur at spawner abundances below the carrying capacity. This density-dependent function directly influences the production of eggs in the model such that when the

spawner abundance is above approximately half the carrying capacity, the production of eggs per spawner will start to decrease as abundance increases. The loss of productivity of eggs per spawner affects the CRR negatively, leading to reduced CRR for higher abundances. Furthermore the mean CRR of the PA is only 0.55 percent greater than the mean CRR of the COS (Figure 2.5.9-6). This number indicates that the population's ability to replace itself is, numerically, slightly improved for the PA, but that is partially driven by the relative decrease in abundance for the PA. Overall, the mean difference in CRR between the PA and COS may be so small that it does not represent a biologically meaningful difference.

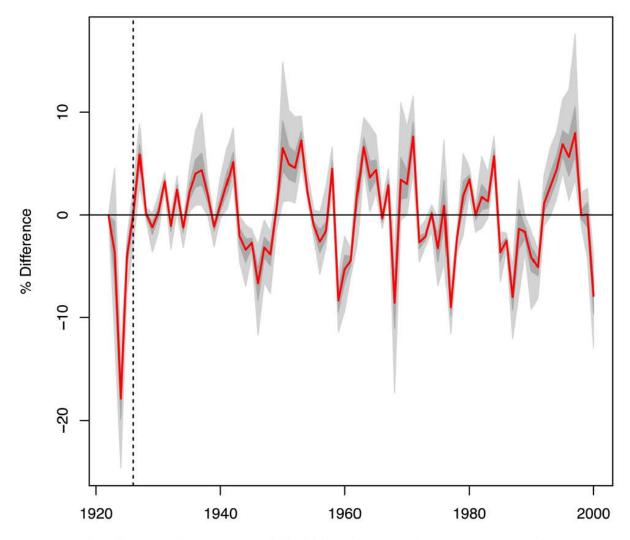
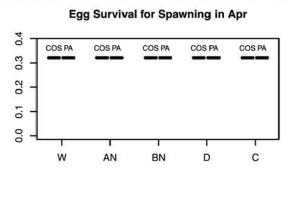
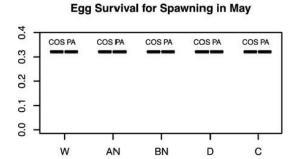


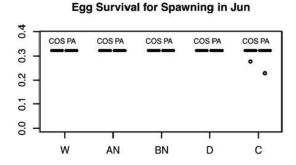
Figure 2.5.9-6. Difference in CRR (i.e., (PA – COS)/COS X 100 percent) for 1,000 paired runs of the WRLCM. Results show median (red line), 50th percentile interval (dark grey) and 95th percent interval (light gray).

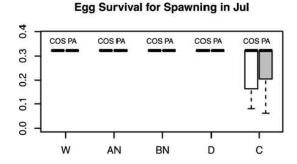
# 2.5.9.2.1.1 Dynamics Leading to Differential Abundance and Productivity

The lower abundance in the PA relative to the COS are largely due to conditions in the non-wet water year types and the month of April in certain lifestages/locations. There is little difference between the PA and COS in the egg-to-fry mortality that occurs in the reach from Keswick Dam to RBDD, except for minor differences in the months of June - August in Critical water year types (Figure 2.5.9-7). During Critical water year types, the model shows that the PA has a decreased median survival, specifically in August (a reduction of 5.6 percent).









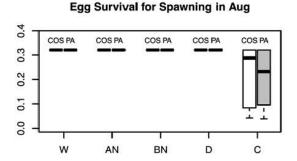
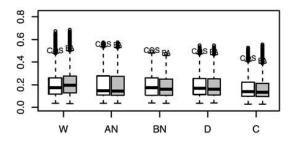


Figure 2.5.9-7. Egg-to-fry survival by month for the COS and PA. For each plot, the x-axis is water year type (Wet, Above Normal, Below Normal, Dry, and Critically Dry) and the y-axis is the proportion of egg survival.

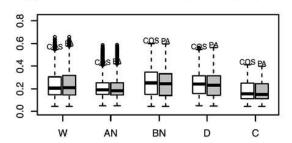
# Biological Opinion for the Long-Term Operation of the CVP and SWP

Likewise, there are small differences in the survival of smolts originating from the Upper River habitat (Figure 2.5.9-8); the Upper River habitat begins below Keswick Dam and ends at the RBDD. In all months and water year types, survival of smolts originating in the Upper River was lower for the PA except for January through March of wet years, when survival for the PA was slightly greater than for the COS (Figure 2.5.9-8). For all water year types, the differences in smolt survival between the PA and COS are very small, being less than 3 percent different except for April of below normal years when COS survival is 3.6 percent greater than the PA.

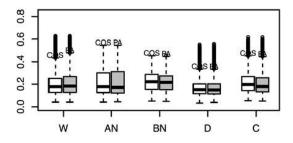
#### Upper River Smolt Survival (origin to Chipps) in Jan



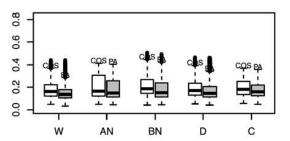
Upper River Smolt Survival (origin to Chipps) in Feb



#### Upper River Smolt Survival (origin to Chipps) in Mar



Upper River Smolt Survival (origin to Chipps) in Apr



Upper River Smolt Survival (origin to Chipps) in May

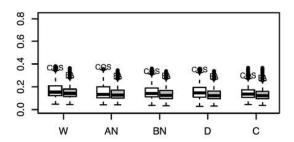


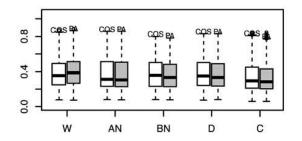
Figure 2.5.9-8. Monthly survival of smolts originating from the Upper River habitat under COS and PA. (In general, survival results of the PA are lower than the COS for a given water year type and month except Jan – March of Wet water year types.) Results are shown for Jan-May for all habitat types and do not imply equal distribution of presence in that habitat type for the full period.

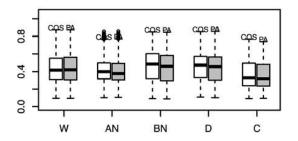
# Biological Opinion for the Long-Term Operation of the CVP and SWP

Similar to the analysis of survival of smolts originating in the Upper River habitats, survival of smolts originating in the Lower River habitats is generally lower for the PA than the COS (Figure 2.5.9-9). The Lower River habitat begins below RBDD and ends at the Delta. Survival for the PA was lower than COS in all months and water year types except for January through March of wet years, when PA survival is slightly greater than COS survival (Figure 2.5.9-9). Of the months examined, April has the greatest difference in survival of smolts originating in the Lower River habitats; in this month, PA survival is 3.6 to 7.5 percent lower than COS survival.

#### Lower River Smolt Survival (origin to Chipps) in Jan

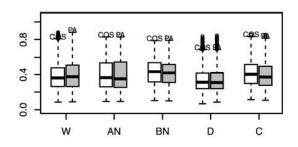
#### Lower River Smolt Survival (origin to Chipps) in Feb

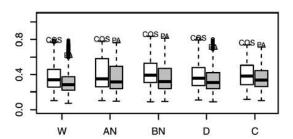




#### Lower River Smolt Survival (origin to Chipps) in Mar

# Lower River Smolt Survival (origin to Chipps) in Apr





#### Lower River Smolt Survival (origin to Chipps) in May

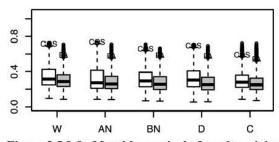
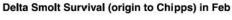
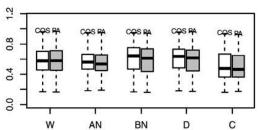


Figure 2.5.9-9. Monthly survival of smolts originating from the Lower River habitat under COS and PA. (In general, survival results of the PA are lower than the COS for a given water year type and month except Jan – March of Wet water year types.) Results are shown for Jan-May for all habitat types and do not imply equal distribution of presence in that habitat type for the full period.

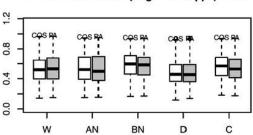
Overall, the results show similar survival for smolts originating from the Delta habitat for both the PA and the COS (Figure 2.5.9-10). Smolts that originate in the Delta have slightly lower median survival for the PA during most months and water year types. All survival differences for the PA relative to the COS are less than 3 percent, except for the month of April, when median survival for the PA is 4.8 to 9.4 percent less than for the COS. The difference in smolt survival for the PA relative to the COS reflects differences in flow in the Delta region. For the PA, higher south Delta export levels influence in-Delta flows, reducing survival relative to the COS; therefore, smolts that originate from the Delta habitat may have slightly higher survival for the COS than the PA (Figure 2.5.9-10).

# Delta Smolt Survival (origin to Chipps) in Jan O W AN BN D C

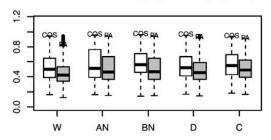








#### Delta Smolt Survival (origin to Chipps) in Apr



#### Delta Smolt Survival (origin to Chipps) in May

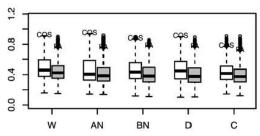
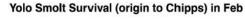
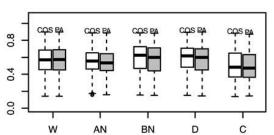


Figure 2.5.9-10. Monthly survival of smolts originating from the Delta Habitat for the COS and PA. In general, survival results of the PA are slightly lower than the COS during most months and water year types. These results are particularly noticeable in April for all water year types. Results are shown for Jan-May for all habitat types and do not imply equal distribution of presence in that habitat type for the full period.

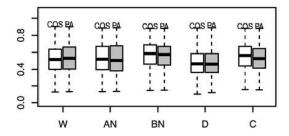
As with the other habitats, smolt survival for the PA is lower than the COS for smolts originating in the Yolo Bypass habitat for all months and water year types, except for January through March of wet years, when the PA survival is slightly greater (Figure 2.5.9-11). The differences in survival between the PA and COS for smolts originating in the Yolo Bypass habitat are greatest in the month of April, when survival for the PA decreases 4.6 to 8.4 percent relative to the COS.

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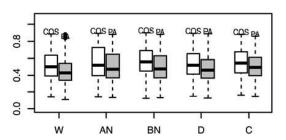








#### Yolo Smolt Survival (origin to Chipps) in Apr



Yolo Smolt Survival (origin to Chipps) in May

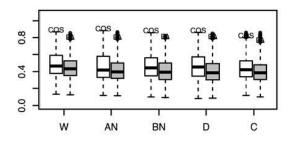


Figure 2.5.9-11. Monthly survival of smolts originating from the Yolo Habitat for the COS and PA. In general, survival results of the PA are lower than the COS during most months and water year types. These results are particularly noticeable in April for all water year types. Results are shown for Jan-May for all habitat types and do not imply equal distribution of presence in that habitat type for the full period.

Overall, smolt survival based on habitat origin is lower for the PA compared to the COS. Whether this difference will affect the population dynamics in the WRLCM depends on the proportion of smolts that originate from particular habitats and the timing of emigration from the habitat or origin. Figure 2.5.9 12 shows the proportion of smolts originating from different habitat areas, including the Upper River, by water year type for the COS and PA. Figure 2.5.9-12 shows that for wet years there is an increase in smolt per spawner for the PA compared to the COS; this difference is largely attributable to smolts originating in the Yolo Bypass habitat. This result highlights the importance of timing, since the PA has lower survival of smolts overall originating from the Yolo Bypass except for January through March of wet years (Figure 2.5.9-11). These differential patterns in habitat use and habitat-specific survival rates result in a slightly higher CRR but lower abundance for the PA relative to the COS.

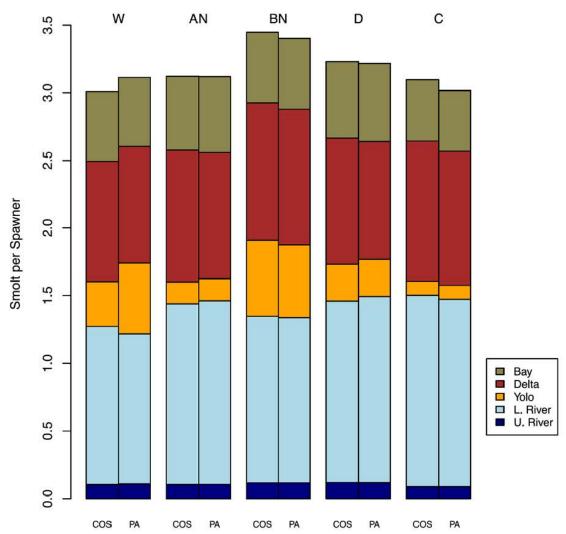


Figure 2.5.9-12. Origin of smolts by water year type for the COS and PA. Colors represent the habitat of origin.

## 2.5.9.2.1.2 Assessment of Population Decline Criteria

Lindley et al. (2007) identified the population decline criteria as a way of assessing demographic risks, where severe and prolonged declines to small run sizes are considered strong evidence that a population is at risk of extinction. The criteria have two components: a downward trend in abundance and a critical run size (i.e., < 500 spawners). A downward trend in abundance is estimated as a 10 percent or greater decline in run size (i.e., abundance) per year. And while Lindley et al. (2007) notes that salmonid populations near a carrying capacity of 500 spawners with only modest intrinsic growth rates are typically at a low probability of extinction, it is important to point out that the threshold of 500 spawners lacks a robust justification. Likewise it is incorrect to equate outputs of the WRLCM to actual numbers of fish in the Sacramento River. Without actual numbers of fish, it is only appropriate to apply the WRLCM to provide guidance on the relative probability of a population decline and it is not a direct application of the Lindley et al. (2007) population decline criteria which includes whether abundance is below the critical run size.

To assess the relative probability of events in which the spawner abundance will decline by at least 10 percent over specified lag intervals of 1, 4, 12, and 20 years, the WRLCM was run for 1,000 iterations to represent multiple "states of nature." That is, in each of the model iterations it was calculated whether the abundance at the subsequent lag interval would have declined by 10 percent or greater. For a given iteration, the number of events with population declines of 10 percent or greater are assigned into three possible categories: (1) the number of events was higher for the COS than the PA, (2) the number of events were equal for the COS and PA, or (3) the number of events were lower for the COS than the PA. The probability of each category is then calculated as the number of iterations in each of the three categories divided by the total number of iterations (i.e., 1,000). The probabilities that result from this analysis do not indicate the specific probability of a decline occurring under each scenario at the specific lag. Instead, they indicate the probability that, over the 75-year timeframe of year 5 to year 82 (WRLCM is initializing in the first 4 years), the PA has fewer, an equal number, or more events than the COS in which the spawner abundance at the specified lag interval will decline 10 or more percent. That is, this metric evaluates the proportion of iterations for which these adverse events occur more often in the PA relative to the COS, occur the same number of times in the PA and COS, or occur less often in the PA than the COS.

Table 2.5.9-1 shows the relative probability of events in which the spawning abundance declines by more than 10 percent over several time periods. The general pattern shows a higher number of events observed in iterations of the PA scenario relative to the number of events observed in iterations of the COS scenario over the 75-year timeframe. This is consistent for spawner abundances at lags of 4 and 12 years, with a shift toward more events for the PA relative to the COS at a lag of 20 years when compared to the other time periods.

Table 2.5.9-1. Relative probability of events in which there is a decline in spawner abundance of greater than 10 percent at time lags of 1, 4, 12, or 20 years for the COS and PA.

	1 Year	4 Years	12 Years	20 Years
Pr (COS has more events)	0.265	0.235	0.296	0.171
Pr (equal number of events)	0.279	0.234	0.26	0.24
Pr (PA has more events)	0.456	0.531	0.444	0.589

This assessment also reflects the higher variability in the spawning abundance in the PA relative to the COS. The variance in spawner abundance for the PA is 6.23 percent higher than for the COS, with a 95 percent confidence interval of -0.263 percent to 12.3 percent relative to the variance of COS spawner abundance. The probability that variance is higher for the PA relative to COS is 0.971. Generally, a higher variance in the average spawner abundance of one scenario relative to another is described by larger swings in the spawner abundance, with higher peaks and lower lows. This pattern is shown in the relative percent difference plot of spawner abundance over time (Figure 2.5.9-5), where the variance is indicated by the year-to-year variability in the differences among years.

# 2.5.9.3 **Summary**

The IOS model and the WRLCM each have strengths and limitations in their ability to capture the dynamics associated with changes in species abundance and productivity in response to changes in physical conditions. Though the mechanistic basis differs between them, and this can lead to different results, we consider the comparative results of both models as lines of evidence in assessing the effects of operations to the species. The IOS results show little difference between the COS and the PA in egg survival, fry survival, or escapement. While the WRLCM shows a very slight increase in CRR for the PA, the abundance for PA operations is on average less than for the COS. This 3 percent difference is not large in magnitude, but it does not support an opposite trend – that abundance of winter-run Chinook salmon would increase for the PA. We note again that while the comparative analysis of these results is useful in terms of understanding the overall direction of modeled effects and assessing predicted trends on population structure and viability, it should not be conflated with an analysis of the full effects of proposed project operations on the species. These results are analyzed in a comparative analysis between the two scenarios to place the difference in context given modeled operations; this difference is incorporated into the evaluation of effects in the aggregate. Considering these results together, NMFS believes that the effects of the operations of the PA would not increase abundance or productivity of winter-run Chinook salmon, but assumes that results would be similar to those of current operations.

#### 2.5.10 Climate Change

In 2016, NMFS issued general policy guidance for treatment of climate change in ESA decisions (Sobeck 2016). This guidance aligns with case law, noting the need to consider climate change in determinations and decisions despite the challenges of climate change uncertainty, and it provides policy considerations related to climate change that NMFS should use in ESA decision making, including ESA section 7 consultations. In addition to Sobeck (2016), NMFS regional guidance (Thom 2016) further recommends use of the Representative Concentration Pathway (RCP) 8.5 scenario from the Fifth Assessment Report (AR5).

The modeling of the PA as provided in the biological assessment characterizes a 2030 scenario of climate conditions, water demands, and build-out. In doing so, the PA uses a multi-model ensemble-informed approach to identify a best estimate of the consensus of climate projections from the third phase of the Coupled Model Intercomparison Project (CMIP3), which informed the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) (U.S. Bureau of Reclamation 2016a). This approach is the same as that used for other recent long-term operations evaluations (and is explained in further detail in Appendix 5.A of the

Environmental Impact Statement for the Bay Delta Conservation). Because the 82-year sample set (1922-2003) of historic hydrology of the CalSimII model period is adjusted to capture the effects projected by the consensus approach, the modeling used in this analysis includes the occurrence of extreme but important events, such as the 1930s and 1990s droughts. These results are downscaled to a spatial resolution of approximately 12 km (7.5 mi). AR4 and its approach results in an anticipated temperature change of +0.7 to +1.4 °C (+1.25 to 2.5 °F) (representing the 25th to 75th quartile) and a precipitation change of -6 percent to +6 percent. Additionally, the approach used in the PA characterizes 2030 sea level rise of 15 cm (6 in) and a 2045 sea level rise of 45 cm (18 in).

However, based on results from the application of RCP 4.5 and RCP 8.5 in California's Fourth Climate Change Assessment (4th CA Assessment) (He et al. 2018, Pierce et al. 2018), NMFS expects that climate conditions will follow a more extreme trajectory of higher temperatures and shifted precipitation into 2030 and beyond. As provided by the 4th CA Assessment, NMFS assumes that temperatures would increase up to 1.9 °C (3.4 °F) between 2020-2059 and precipitation changes would range from -6 percent to +24 percent in the same period (He et al. 2018). Sea level rise is expected to range up to 15 cm (6 in) in 2030 and 10-38 cm (4-15 cm) in 2050 (Pierce et al. 2018). This assessment uses CMIP5, which supersedes the CMIP3 archive of climate models scenarios used in in the previous California Climate Assessment, and better comports with NMFS and WCR guidance on incorporating climate change into ESA decisions.

It is beyond NMFS' expertise, scope, and resources to develop model simulations that reflect the more updated climate projections provided in the 4th CA Assessment. This would require modifications to the base meteorological and hydrologic modeling that is the first, if not one of the very early, steps in the chain of models used to provide analytical tools to support the modeling (see Section 2.1.4.1 Primary Analytical Models for description of models used and data flow).

There is a notable difference in the projected air temperature increases between the modeling used for the BA and the 4th CA Assessment. Compared to the BA, the updated projected temperatures for the shorter-term (2025) in the 4th CA Assessment increase by more than 30 percent more; the difference in projections is nearly a full degree Celsius warmer for the longerterm at 2100. These increases in air temperature can be expected to directly affect cold water pool and reservoir temperatures because of shifts to warmer storms, earlier snow melt, and increased or earlier solar warming of water in the reservoir. This would affect reservoir stratification and cold water pool setup, possibly beyond what can be predicted based on current understanding. Additionally, in-river summer water temperatures are already at levels that present challenges in managing to protect the species. Considering the 4th CA Assessment, NMFS expects that in-river temperatures will be even greater than what was presented in the BA modeling; this will increase the management challenges in late-summer and fall months as reservoir cold water pools deplete over summer in efforts to keep downstream temperatures within a suitable range. NMFS cannot quantify the effect of this on species, but will assume that the provided modeling represents a scenario of lower effect and will layer additional qualitative evaluations of increased climate effects to the species based on the updated assessments.

The BA modeling and the 4th CA Assessment projections of sea level rise are similar for 2030, but have greater differences for later projections. The higher projection of sea level rise in the 4th CA Assessment in the long-term 2100 scenario can be expected to increase salinity and tidal

forcing in the estuary and Delta, which will reduce the effects of riverine flow. The difference in the 4th CA Assessment is especially apparent. No large-scale tidal restoration is included in the proposed action as designed to address this. It is, therefore, conceivable to expect modifications to proposed operations due to higher frequency of water quality excursions influenced by increased saltwater intrusion. There is also expected to be less seaward flow in highly tidal areas and tidally-influenced areas like the south Delta. Therefore, what was analyzed in the modeling of the biological assessment is considered by NMFS as the scenario of lower effect and consistent with the 4th CA Assessment for 2030; however, it is considered as an absolute lower effect for late 2000s when the assessment projects much greater increases in sea level rise than those captured in the modeling of 2030 in the BA.

The effects of climate change are evaluated as imposed upon the behavior and distribution of the species as we understand it today. NMFS has not speculated, for instance, if and how species will adjust their migration timing to upstream reaches in response to changing climate conditions. Nor have we made any assumptions regarding species presence and density in response to changing conditions. Any shifts in species behavior and distribution that present conditions that are beyond the bounds of our analysis could be a reinitiation trigger, as the environmental baseline and status of species upon which we based this analysis would no longer be valid.

#### 2.6 Effects of the Action on Critical Habitat

This section addresses impacts to designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon (see maps of critical habitat in Appendix M). The detailed analysis of stressors to the species is contained in Section 2.5 Effects of the Action on Species and will be referred to throughout this section as those analyses are relevant to the impacts to critical habitat. In many cases, the species effects analysis is relied on as underlying support for the critical habitat analysis. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure, and condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure, response, risk), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles is likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

#### 2.6.1 Physical and Biological Features of Listed Central Valley Species

Winter-run Chinook salmon PBFs (as discussed in the Section 2.2 Range-wide Status of the Species) include: (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River, (2) the availability of clean gravel for spawning substrate, (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, (4) water temperatures between 42.5 and 57.5°F (5.8 and 14.1°C) for successful spawning, egg incubation, and fry development, (5) habitat and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean.

Critical habitat for CCV steelhead was designated concurrently with CV spring-run Chinook salmon, and they share the same PBFs²⁸. The PBFs for CCV steelhead are generally related to the same habitat types as the other listed salmonids, but are described with more specificity in the designation. Table 2.6-1 lists specific PBFs that correspond to ESA-listed critical habitat for CV spring-run Chinook salmon and CCV steelhead within the associated habitat category.

Table 2.6.1-1. Summary of PBFs for ESA-listed CV spring-run Chinook salmon and CCV steelhead in the Central Valley.

Habitat	PBFs
Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Fry	Freshwater Spawning Sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.
Freshwater Rearing Habitat for Juveniles	Freshwater Rearing Sites with (i) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) water quality and forage supporting juvenile development; and (iii) natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults	Freshwater Migration Corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

7414) replace this term with physical or biological features (PBFs). This shift in terminology does not change the approach used in conducting our analysis, whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

²⁸ The designations of critical habitat for CV spring-run Chinook salmon, CCV steelhead and green sturgeon use the term primary constituent elements (PCE) or essential features. The new critical habitat regulations (81 FR

Habitat	PBFs
Estuarine Habitat for Rearing and Migration	Estuarine areas free of obstruction and excessive predation with: (i) water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Impacts to designated critical habitat sDPS green sturgeon is discussed in terms of the following PBFs for freshwater riverine and estuarine habitats.

#### **Freshwater Riverine Habitats**

- 1) Food resources. Abundant prey items for larval, juvenile, subadult, and adult life stages.
- 2) Substrate type or size (i.e., structural features of substrates). Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high flow conditions), and feeding of juveniles, subadults, and adults (e.g., sand/mud substrates).
- 3) Water flow. A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages.
- 4) Water quality. Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.
- 5) Migratory corridor. A migratory pathway necessary for the safe and timely passage of all life stages within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage).
- 6) Depth. Deep ( $\geq 5$  m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish.
- 7) Sediment quality. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

#### **Estuarine Habitats**

1) Food resources. Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages.

- 2) Water flow. Within bays and estuaries adjacent to the Sacramento River (i.e., the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds.
- 3) Water quality. Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.
- 4) Migratory corridor. A migratory pathway necessary for the safe and timely passage of all life stages within estuarine habitats and between estuarine and riverine or marine habitats.
- 5) Depth. A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages.
- 6) Sediment quality. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Discussion of effects of the components of the PA on each species are delineated by PBF and are presented by division below. Differences in habitat impacts are generally due to the spatial and temporal distribution of each species within the action area. In some cases, effects to one or more components of a PBF apply in the same way to each species' habitat.

## 2.6.2 Upper Sacramento/Shasta Division

Critical habitat impacted by the proposed action includes the Sacramento River from Keswick Dam to the Delta (301 miles). This stretch of the Sacramento River provides three general habitat types essential to one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead and sDPS green sturgeon.

## 2.6.2.1 Effects to Designated Critical Habitat PBFs for ESA-listed Salmonids

This section examines impacts to designated critical habitat for winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. Critical habitat for both CV spring-run Chinook salmon and CCV steelhead was designated concurrently, and they share the same PBFs. The PBFs for winter-run Chinook salmon are related and similar to the habitat types of the other listed salmonids, but they were described with more specificity at designation. Here, the general habitat types that occur within the action area provide the structure for the assessment of habitat impacts for all salmonids. For each habitat type, and each fish species, the specific PBFs that correspond to ESA-listed critical habitat are identified. Where there is discussion of effects to a specific component of a PBF, these are delineated by species. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure, and condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure, response, risk), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles is likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

# 2.6.2.1.1 Effects to Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Fry Sacramento River winter-run Chinook salmon PBFs:

- Availability of clean gravel for spawning substrate
- Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles
- Water temperatures between 42.5–57.5°F (5.8–14.1°C) for successful spawning, egg incubation, and fry development

### CV spring-run Chinook salmon and CCV steelhead PBFs:

Freshwater Spawning Sites

Freshwater spawning habitat for all three species occurs in the upper reaches of the Sacramento River from Keswick Dam to RBDD. The available spawning area for salmonids in this region is greatly limited by the existence of impassible barriers like Keswick and Shasta dams. Spawning habitat is further constrained by the availability of suitable temperatures during each species respective spawning season, such that in the Sacramento River it is limited to a smaller area below Keswick Dam.

The existence of Shasta and Keswick dams also limit recruitment of clean gravel for spawning substrate as the block the downstream transport of gravels to the accessible reach of the river. Clean gravel is available from upstream supply deposited from tributaries and gravel augmentation projects, and from flows high enough to flush finer sediment out of gravels beds, but not so high as to transport gravel out of the spawning area. Flows under the PA are generally similar to the COS and are unlikely to affect the amount of upstream gravel supplied by the tributaries or unregulated pulse flows. Reclamation's proposed spring pulse flow described in Section 2.5.2.3.2.3 could provide flows high enough to flush fine sediments from spawning substrates, but the expected frequency of these regulated flows is limited in the years that would not otherwise have a natural spring pulse. In addition to operational measures that could affect the availability of spawning gravel, the PA also includes a number of projects to improve spawning habitat for Chinook salmon in the upper Sacramento River. Although the occurrence of these projects is uncertain, it is likely that they would enhance availability of clean gravel for salmon spawning and are considered in the analysis of the proposed action.

Flows in upper reach of the Sacramento River are similar for both the PA and COS and they are generally sufficient to provide for the successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles. However, risk of redd dewatering is considered, especially with regards to swift reductions in flows during incubation periods. In their analysis, Reclamation provided an assessment of spawning WUA for all Sacramento River salmonid species. Spawning WUA provides a metric of spawning habitat capacity that accounts for the spawning requirements of the fish with respect to water depth, flow velocity, and substrate. Spawning WUA for all three species of salmonids was determined by USFWS (2003, 2006) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence. Although the validity of the steelhead WUA is less certain because of the difficulty in differentiating between steelhead and rainbow trout spawning (USFWS, 2003). Segment 4 stretches 8 miles from Battle Creek to the confluence with Cow Creek, Segment 5 reaches 16 miles from Cow Creek to the ACID Dam, and Segment 6 covers 2 miles from ACID Dam to Keswick Dam. Results are based on flow differences between the PA and COS with summary results combining all year types presented in Table 2.6.2-1. For winter-run Chinook salmon spawning habitat, decreased flows in September under the PA result in a

decreased spawning WUA in segment 6 but an increase in spawning WUA in segment 5. For CV spring-run Chinook salmon spawning habitat, the months of September and November, when flows are reduced under the PA, show improved WUA for both river segments 5 and 6. CCV steelhead spawning habitat also shows improved WUA in November when the PA reduces Keswick releases, but otherwise there is slightly reduced WUA under the PA.

Table 2.6.2-1. Weighted Usable Area (WUA) results for Segments 5 and 6 for salmonid species in the upper Sacramento River. Information provided by Reclamation. Red indicates decrease in 5 or more percent; green indicates increase in 5 or more percent.

			Segment 6			Segment 5	
Species	Month	COS5	PA20	PA20 vs. COS5	COS5	PA20	PA20 vs. COS5
Winter-run	April	152,681	167,522	14841 (10%)	611,758	625,885	14127 (2.3%)
	May	268,429	274,858	6429 (2%)	765,140	765,962	822 (0.1%)
	June	296,167	290,571	-5596 (-2%)	759,746	724,260	-35486 (- 4.7%)
	July	284,926	287,006	2080 (0.7%)	636,966	646,418	9452 (1.5%)
	August	298,982	297,206	-1776 (-0.6%)	774,943	775,706	763 (0.1%)
	September	237,708	224,608	-13100 (- 5.5%)	678,419	724,884	46465 (6.8%)
	October	238,206	236,731	-1475 (-0.6%)	748,370	748,740	370 (0%)
CV	August	265,774	267,457	1683 (1%)	399,815	399,362	-453 (-0.1%)
Spring-run	September	265,823	301,301	35478 (13%)	430,673	542,720	112047 (26%)
	October	302,466	305,101	2635 (1%)	532,966	536,539	3573 (0.7%)
	November	160,675	196,159	35484 (22.1%)	466,553	547,148	80596 (17.3%)
	December	209,728	183,838	-25890 (- 12.3%)	466,753	457,161	-9592 (-2.1%)
CCV Steelhead	November	54,219	58,465	4246 (8%)	145,851	156,235	10384 (7.1%)
	December	55,389	51,426	-3963 (-7%)	137,830	133,910	-3920 (-2.8%)
	January	53,045	49,463	-3583 (-7%)	128,573	126,089	-2483 (-1.9%)
	February	49,420	47,132	-2288 (-4.6%)	116,522	117,445	923 (0.8%)
	March	53,270	52,951	-319 (-0.6%)	130,983	129,969	-1014 (-0.8%)
	April	110,197	109,431	-766 (-0.7%)	155,134	156,297	1163 (0.7%)

Water temperatures play a significant role in the function of salmonid spawning habitat. Both the COS and the PA can provide for suitable temperatures for spawning, egg incubation, and fry development based on the modeling. This is primarily attributed to the proposed temperature management modeling which shows an increased early summer storage volume, which could increase the frequency of meeting temperature criteria during the late spring, summer and early fall period. However, there are uncertainties in this characterization of operations, as noted in Section 2.5.2.1.2. Projects Uncertainties. Even with the prescience associated with the hydrologic modeling, there are still months and years when temperatures are not suitable for spawning, egg incubation, and fry development. This is expected to will lead to reduced spawning success and reduced survival of eggs and fry. The impacts to species of these temperature exceedances are described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management. Of particular concern are temperatures in the months of August – October, which corresponds to peak CV spring-run Chinook salmon spawning and egg incubation in the upper Sacramento River. These months tend to have the warmest water temperatures for both the COS and PA; in critical water years, temperatures consistently exceed the upper limit of the temperature-related critical habitat PBF for spawning, egg incubation, and fry development (i.e., 57.5°F).

### 2.6.2.1.2 Effects to Freshwater Rearing Habitat for Juveniles

#### Sacramento River winter-run Chinook PBFs:

- Habitat areas and adequate prey that are not contaminated
- Riparian habitat that provides for successful juvenile development and survival

### CV spring-run Chinook and CCV steelhead PBFs:

Freshwater Rearing Sites

Freshwater rearing habitat occurs for all three salmonid species in the mainstem Sacramento River downstream to the Delta. Neither the PA nor the COS are likely to affect contaminant levels or sources in the action area. Primary sources of contaminants in the Sacramento River are from non-point source runoff and drainages from agriculture and municipalities, which are described in Section 2.7 Cumulative Effects. While relative changes in the volume of flows influence contaminant sources, as flow can affect the concentration or dilution of contaminants, flows under the PA are generally similar to the COS and are unlikely to affect the concentration of contaminants entering the river.

The availability of freshwater riparian habitat that provides for successful juvenile development and survival is also affected by flow. Rearing WUA analysis for Sacramento River segments 6 (ACID Dam to Keswick Dam) and 5 (Cow Creek to the ACID Dam) show varying degrees of habitat capacity but no discernable trend between the COS and PA. The exception is CV springrun Chinook salmon and CCV steelhead rearing WUA in the upper Sacramento River during the months of January and February when both species are beginning to emigrate. For those months, the rearing WUA of the PA is somewhat less than the COS indicating a lower overall quality of available rearing habitat in the upper Sacramento River under the PA.

While WUA provides a metric of habitat quality, an indicator of the available quantity of riparian habitat is floodplain inundation. Results of floodplain inundation analyses based on the mean monthly inundation for the upper, middle and lower Sacramento River as well as the bypasses

(Sutter and Yolo). A general trend across all locations is that the differences in mean floodplain inundation is usually very small when comparing the COS to PA. For the upper, middle and lower Sacramento River, the amount of floodplain inundation is usually the same or greater under the PA from December through August, while the opposite is the case from September through November. Although the absolute differences are very small, the relative decrease in floodplain inundation during the September to November timeframe is important for winter-run Chinook salmon because this is the period when the majority of juveniles are rearing in the river or migrating to the Delta. Inundation analysis for the Sutter and Yolo bypasses show very little difference between the COS and the PA. CalSimII results for Fremont Weir spill show a slight increase in the monthly flow on to the Yolo Bypass for the PA compared to the COS in November through March; this would provide a small increase in freshwater rearing habitat for all juvenile salmonids.

For both the COS and the PA the dynamic natural flows that would occur in the spring and that result from unregulated tributary contributions have been replaced by a single minimum flow that is sufficient to maintain aquatic species during crucial low-flow periods. The species the effect of this contrast, between the historic unmodified flows and the minimum flows in the mainstem, is described in Section 2.5.2.3.2.2 (Spring Base Flows). And although necessary to build sufficient storage to provide adequate spawning and incubation temperatures in the summer, the minimum spring flows of both the COS and PA reduce the extent of floodplain inundation and the availability of freshwater rearing habitat in the spring. As the pre-dam hydrograph in Figure 2.5.2 2 shows, the median monthly flows for February through April (above about 15,000 cfs) were nearly double the managed flow into the upper Sacramento post-dam construction and the modeled for both the COS and PA where flows median at Bend Bridge range between 10,600 cfs and 6,300 cfs. This reduction in spring flow, which reduces the extent of floodplain inundation, continues to be a significant constraint on freshwater rearing habitat availability for all salmonids.

# 2.6.2.1.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

#### Sacramento River winter-run Chinook salmon PBFs:

- Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles
- Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River
- Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean

### CV spring-run Chinook salmon and CCV steelhead PBFs:

Freshwater Migration Corridors

A functioning migration corridor for the emigration of juvenile salmonids from the upper Sacramento River to the Delta and for the immigration of adult salmonids to the upper Sacramento River and its tributaries is dependent on the condition of flows, temperature, and the presence of impediments.

Flows in the Sacramento River for the PA are sufficient to maintain access both to and from the spawning habitat in the upper river. Differences in modeled flows are small between the PA and COS, with the largest differences occurring in September and November when PA flows are significantly lower than the COS. The September to November period corresponds to the peak of winter-run Chinook salmon juvenile migration past RBDD, so decreased river flow at this time would reduce the transport of winter-run Chinook salmon out of the upper river. This relationship of flow and transport/travel time is described in BA Section 5.8.3.3 (Spring Pulse Flows), where it is hypothesized that increased travel time results in a decrease in survival because of increased interaction with predators. This same relationship is the basis of the benefits described in Section 2.5.2.3.2.3 Spring Pulse Flows of this Opinion. The pulses are expected to provide improved migration corridor habitat conditions from March 1 to May 15 for CV springrun Chinook salmon and CCV steelhead juveniles in years where a spring pulse flow is implemented.

Modeled water temperatures are generally adequate in the middle and upper Sacramento River for immigrating adult salmonids during the early portion of their respective migration periods. Starting in May and through the summer, temperatures in the middle reaches of the river begin to increase, and they can exceed temperatures that accommodate volitional migration and subsequently can impede adult upstream migration. During this period, conditions for the PA are slightly improved over the COS but could still pose an impediment to adult migration. These effects may be partially mitigated by the habitat restoration components of the PA which could provide improvement to temperatures in the Freshwater Migration Corridor habitat. In particular, channel margin restoration and the spawning and rearing habitat enhancement projects could provide additional instream cover that would improve river conditions. However, these PA components have been proposed as programmatic actions and both the effects and the likelihood of implementation are uncertain.

Unscreened diversions in the Sacramento River also pose an impediment to migration since fish can be entrained into unscreened or poorly screened diversions. To address this issue, Reclamation has proposed a number of projects to screen diversions or modify existing screens in Sacramento River. Though these projects are expected to improve conditions in the migratory corridor habitat, the uncertainty of the timing of these projects and their extent of effect prevents them from being considered in this Opinion.

#### 2.6.2.2 Effects to sDPS Green Sturgeon Critical Habitat

Critical habitat for the sDPS green sturgeon includes PBFs that describe features of habitat types for multiple life stages. This section is structured similarly to Section 2.6.2.1 Effects to Critical Habitat for ESA-Listed Salmonids. Specific PBFs that are present in the action area are identified within each general habitat type and described in the context of each life stage. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure, and condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure, response, risk), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles is likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

# 2.6.2.2.1 Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Larvae sDPS green sturgeon PBFs

- · Water Quality
- Water Flow
- Substrate Type or Size

Spawning habitat occurs for sDPS green sturgeon in the upper reaches of the Sacramento River concentrated between Glenn Colusa Irrigation District (GCID)/Hamilton City, upstream to Cottonwood Creek (see Section 2.2 Rangewide Status of the Species and Critical Habitat).

As discussed in Section 2.5.2.3.3.1 Summer Cold Water Pool Management, modeled water temperatures in the upper Sacramento River for the PA are expected to negatively affect the critical habitat water quality PBF used by early life stages in the Sacramento River during some years. Overall, the lethal threshold of 71.5°F for eggs and larvae is exceeded in less than 1 percent of days at Hamilton City (most downstream recorded spawning event), but the threshold for sublethal effects, 63.5°F, would be exceeded in 39 percent of days at Hamilton City. Actual temperature effects in sDPS green sturgeon critical habitat are expected to be less significant than modeled effects since spawning occurs in deep pools which are insulated from degradation of the spawning habitat water quality PBF. The water flow PBF of sDPS green sturgeon critical habitat is not expected to be negatively affected by the PA, since flows in the spawning region (Cottonwood Creek to Hamilton City) during the spawning period (April to July) are sufficient for spawning adults and rearing larvae.

The PA includes a number of proposed habitat restoration actions that could restore, add, or otherwise improve spawning gravel within the primary spawning range for green sturgeon in the Sacramento River. With regard to the substrate type or size PBF, channel margin restoration and the spawning and rearing habitat enhancement projects could provide additional sources of suitable spawning gravel that would improve river spawning conditions. However, because these PA components have been proposed as programmatic actions, the effects and likelihood of implementation are uncertain.

# 2.6.2.2.2 Freshwater Rearing Habitat for Juveniles and Subadults sDPS green sturgeon PBFs

- Water Quality
- Water Flow
- Food Resources
- Sediment Quality
- Depth

Based on laboratory studies of northern DPS green sturgeon, optimal bioenergetic performance for juvenile green sturgeon (including growth, metabolic rate, temperature preference, and swimming performance) occurs at 15°C to 19°C (Mayfield and Cech 2004). Based on the May to October timing of larval and juvenile occurrence in the Sacramento River at GCID (Poytress et al. 2015), the predicted range of water temperatures in the upper to middle Sacramento River for the PA is expected to have a small but negative effect on the water quality critical habitat PBF used by juveniles for rearing. Overall, the PA is expected to exceed the optimal temperature for bioenergetic performance of sDPS green sturgeon in 7 percent of days in May through October.

The water flow PBF of sDPS green sturgeon critical habitat is also related to the food resources, sediment quality, and depth PBFs because water flow can determine access to the quantity and quality of the other PBFs in the freshwater rearing habitat. Changes to floodplain inundation is a metric used to measure the overall quantity of riparian habitat and the relative access to the PBFs of food resources, sediment quality, and depth. Results of floodplain inundation analyses for the upper, middle and lower Sacramento River as well as the Sutter and Yolo bypasses show very small differences in mean floodplain inundation between the COS and PA. For the upper, middle, and lower Sacramento River, the amount of floodplain inundation is usually the same or greater for the PA in December through August, while the opposite is the case in September through November. Inundation analysis for the Sutter and Yolo bypasses show very little difference between the COS and the PA. CalSimII results for Fremont Weir spill show a slight increase in the monthly flow on to the Yolo Bypass for the PA compared to the COS in November to March. This is expected to provide a small increase in freshwater rearing habitat for juvenile sDPS green sturgeon. Overall, the PA provides a sufficient flow regime that promotes the normal behavior, growth, and survival of all sDPS green sturgeon life stages.

# 2.6.2.2.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

- Migratory Corridor
- Sediment Quality
- Depth

Freshwater migratory corridors for sDPS green sturgeon are those migratory corridors linking estuarine habitat in the Delta with the spawning habitat in upstream spawning reaches of the Sacramento River. Unscreened diversions in the Sacramento River pose a potential impediment to migration since fish can be entrained into unscreened or poorly screened diversions. To address this issue, Reclamation has proposed projects to screen diversions or modify existing screens in Sacramento River.

Thought these projects are expected to improve conditions in the migratory corridor habitat, the uncertainty of the timing of these projects and their extent of effect prevents them from being considered in this opinion.

#### 2.6.3 Trinity River Division (Clear Creek and Spring Creek Debris Dam)

### 2.6.3.1 Effects to Designated Critical Habitat PBFs for ESA-listed Salmonids

Clear Creek is designated critical habitat for CV spring-run Chinook salmon and CCV steelhead. The PBFs of designated critical habitat in Clear Creek include (1) freshwater spawning sites, (2) freshwater rearing sites, and (3) freshwater migration corridors. This analysis of effects of the PA on critical habitat is based on the species effects analysis in Section 2.5, and is summarized as they relate to the PBFs of critical habitat, in Table 2.6.3-1 for CV spring-run Chinook salmon and Table 2.6.3-2 for CCV steelhead. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure, and condition of the habitat to support that life-stage, we use the species effects analysis conclusions (exposure, response, risk), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles is likely to result in reduced growth/survival, the effect to critical

habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

Table 2.6.3-1. Summary of responses of Clear Creek CV spring-run Chinook salmon to the proposed action and probable change in PBF

Action Component	PBFs Affected	Response	Probable Change in PBF
Water temperature management: Fall	Fresh water spawning sites	Spawning temperature criterion (56°F) is suboptimal and exceedance further degrades spawning habitat. Greatest impact to habitat downstream of compliance point, and in Critical water year types.	Reduced quantity and quality of spawning habitat.
Minimum instream base flows	Fresh water spawning sites	Base flows provide suitable spawning habitat, but lack variation that provides habitat complexity. In Critical water year types, reduced base flows will degrade spawning habitat.	Reduced quantity and quality of spawning habitat.
Spring attraction pulse flows	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat.	Some increased quality and quantity of spawning habitat.
Channel maintenance pulse flows	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat. Magnitude and duration are not likely to be great enough to shape the channel and adequately route spawning gravel and improve spawning habitat.	Some increased quality and quantity of spawning habitat. Continued degradation of spawning habitat if flows are not of magnitude to shape the channel.
Water temperature management: Summer	Fresh water rearing sites	Exceedance of water temperature criterion (60°F) downstream of compliance point degrades juvenile rearing habitat.	Reduced quality of rearing habitat.
Minimum instream base flows	Fresh water rearing sites	Lack of variability leads to reduced habitat complexity. In Critical years, reduced base flows and less rearing habitat.	Reduced quantity and quality rearing habitat.
Spring attraction pulse flows	Fresh water rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability.	Improved connectivity to rearing habitat temporarily.
Spring attraction pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat.	Degraded rearing habitat.

Action Component	PBFs Affected	Response	Probable Change in PBF
Channel maintenance pulse flows	Fresh water rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability.  Magnitude, duration, and frequency is not likely to be great enough to shape the channel and inundate floodplains to improve or increase rearing habitat long-term.	Improved connectivity and increase available rearing habitat temporarily. Continued degradation of rearing habitat if flows are not of magnitude to shape the channel.
Channel maintenance pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat.	Degraded rearing habitat.
Water temperature management: Summer	Freshwater migration corridors	Exceedance of water temperature criterion (60°F) downstream of compliance point degrades adult holding habitat.	Reduced quality of holding habitat in migratory corridor.
Water temperature management: Summer	Freshwater migration corridors	Warm water may block upstream adult migration, or juvenile emigration near confluence.	Degraded migratory corridor.
Water temperature management: Fall	Freshwater migration corridors	Decreased water temperatures may improve conditions for migration.	Improved migratory corridor for juveniles and adults.
Minimum instream base flows	Freshwater migration corridors	Flows may lack variability to create cues for juvenile emigration and adult migration, especially in Critical and Dry water year types.	Reduced quality of migration corridor.
Spring attraction pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Improved migratory corridor for adults and juveniles temporarily.
Channel maintenance pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Improved migratory corridor.

Table 2.6.3-2. Summary of responses of Clear Creek CCV steelhead to the proposed action and probable change in PBF.

Action Component	PBFs Affected	Response	Probable Change in PBF
Minimum instream base flows	Fresh water spawning sites	Base flows provide suitable spawning habitat, but lack variation that provides habitat complexity. In Critical water year types, reduced base flows will degrade spawning habitat.	Reduced quantity and quality of spawning habitat.
Spring attraction pulse flows	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat.	Some increased quality and quantity of spawning habitat.
Channel maintenance pulse flows	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat. Magnitude and duration is not likely to be great enough to shape the channel and adequately route spawning gravel and improve spawning habitat.	Some increased quality and quantity of spawning habitat. Continued degradation of spawning habitat if flows are not of magnitude to shape the channel.
Water temperature management: Summer	Fresh water rearing sites	Warm water temperatures downstream of temperature compliance point degrade juvenile rearing habitat.	Reduced quality of rearing habitat
Minimum instream base flows	Fresh water rearing sites	Lack of flow variability leads to reduced habitat complexity. In Critical years, reduced base flows will reduce available rearing habitat.	Reduced quantity and quality rearing habitat
Spring attraction pulse flows	Fresh water rearing sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat.	Some increased quality and quantity of spawning habitat.
Spring attraction pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat. Ramping rate will be used.	Degraded rearing habitat.
Channel maintenance pulse flows	Fresh water rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability.  Magnitude, duration, and frequency is not likely to be great enough to shape the channel and inundate floodplains to improve or increase rearing habitat long-term.	Improved connectivity and increased available rearing habitat temporarily. Continued degradation of rearing habitat if flows are not of magnitude to shape the channel.

Action Component	PBFs Affected	Response	Probable Change in PBF
Channel maintenance pulse flows	Fresh water rearing sites	Ramp down following pulse flow create stranding habitat. Ramping rate will be used.	Degraded rearing habitat.
Water temperature management: Summer	Freshwater migration corridors	Warm water may block adult migration near mouth.	Degraded migratory corridor.
Water temperature management: Fall	Freshwater migration corridors	Decreased temperatures may improve conditions for migration.	Improved migratory corridor for juveniles and adults.
Minimum instream base flows	Freshwater migration corridors	Flows may lack variability to create cues for juvenile emigration and adult migration, especially in Critical and Dry water year types.	Reduced quality of migration corridor.
Spring attraction pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Improved migratory corridor for adults and juveniles temporarily.
Channel maintenance pulse flows	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes	Improved migratory corridor temporarily.

### 2.6.3.1.1 Freshwater Spawning Sites

Water temperatures, flow conditions, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration, are stressors that degrade the freshwater spawning habitat PBFs for adult CV spring-run Chinook salmon and CCV steelhead in Clear Creek. The current spawning habitat PBFs for CV spring-run Chinook salmon is degraded due to water temperatures because (1) PA spawning criterion (56°F) is suboptimal, (2) in some years, water temperatures are elevated above the spawning criteria, and (3) elevated water temperatures are higher and occur more frequently in spawning habitat downstream of the compliance point. Under the PA, water temperatures are expected to continue to degrade CV spring-run spawning habitat, especially in Critical and Dry water year types.

The proposed minimum instream base flows provide adequate habitat for spawning for CV spring-run Chinook salmon and CCV steelhead, based on the WUA assessment (U.S. Fish and Wildlife Service 2015a, Unger 2019). However, lack of flow variation prohibits the creation of channel complexity, degrading spawning habitat over time. In Critical water year types, minimum instream base flows would be reduced, resulting in degradation of spawning habitat PBFs including CV spring-run Chinook salmon or CCV steelhead redd dewatering.

Whiskeytown Dam blocks recruitment and transportation of coarse sediment into Clear Creek and, thereby, reduces available spawning habitat for CV spring-run Chinook salmon and CCV steelhead. Injection gravel has been added annually to Clear Creek since 1996 (approximately

176,000 tons) and is dependent on high creek flows for transport downstream, to develop complex features and hydrologic conditions for spawning habitat (Graham Matthews & Associates 2011). Beneficial effects of gravel injection observed in Clear Creek include creation of complex flow patterns and bar sequences, decrease in riparian confinement, increased mobility of armored riffles, and increased floodplain connectivity (Graham Matthews & Associates 2013). In an evaluation of sediment transport in Clear Creek, Graham Matthews & Associates (2013) findings showed that recent spring attraction pulse flows near 1,000 cfs mobilized injection gravel, and provided some value for channel maintenance.

Under the PA, both spring attraction and channel maintenance, are expected to improve spawning habitat quality and quantity by mobilizing and dispersing gravel to some degree, and reducing fine sediment. However, channel maintenance pulse flows under the PA will not occur in Critical and Dry water year types, and would not provide the magnitude needed for channel shaping, floodplain inundation, and improved ecological function of the channel (3,000 to 6,000 cfs), because releases are limited by the outlet capacity at Whiskeytown Dam (900 cfs). Therefore, channel maintenance pulse flows are expected to provide some improvement to the spawning habitat PBF. Although some benefits are expected in a low number of years, pulse flows are not expected to substantially benefit the freshwater spawning site PBFs because the magnitude and duration of the pulse flows are not expected to be great enough to shape the channel and adequately route spawning gravel.

#### 2.6.3.1.2 Freshwater Rearing Habitat for Juveniles

Water temperatures, flow conditions, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration are stressors that degrade the freshwater rearing habitat PBFs for juvenile CV spring-run Chinook salmon and CCV steelhead in Clear Creek. The PA minimum instream base flows generally provide suitable water temperatures with constant, year-round flows that contain adequate access to rearing habitat. However, the PA base flows do not provide the complexity needed for preferable rearing habitat that provides access to floodplains and additional rearing habitat, which would lead to increased growth and provides refugia from predators.

Channel maintenance pulse flows and spring-attraction pulse flows will increase flow variation, which will provide some geomorphic benefit that improves the quality and quantity of the freshwater rearing habitat PBFs, and increases the amount of rearing habitat for a short duration in the winter and spring months. While temporary, access to habitat with more complexity provides protection from predators, resources for increased growth and survival. The pulse flows also result in degraded rearing habitat PBFs from stranding or isolating juveniles when flows are lowered, especially if no gradual ramp down methods are implemented. Down-ramping rates will be implemented, which will reduce stranding risk and minimize negative impacts on survival from flow decreases, and therefore we expected minor impacts to rearing habitat PBFs as a result of the PA.

Water temperature management under the PA would provide suitable rearing habitat in all but the lowest section of Clear Creek. Water temperatures in the lower watershed are expected to be warm and suboptimal for rearing and growth in the summer months, which degrades the rearing habitat. Warmer temperatures in this rearing habitat is expected to increase the likelihood of predation by providing habitat more suitable for warm-water predatory fishes.

Under the PA, lack flow variability will continue to negatively affect rearing habitat in Clear Creek for juvenile CV spring-run Chinook salmon and CCV steelhead.

# 2.6.3.1.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Water temperatures, flow conditions, loss of natural river morphology and function, loss of floodplain habitat, and physical habitat alteration are stressors that degrade the freshwater migratory corridor PBFs for CV spring-run Chinook salmon and CCV steelhead in Clear Creek. Migratory habitat PBFs for adults and juveniles is expected to be impaired downstream of the compliance point from June through August under the PA, due to water temperatures that exceed optimal migration conditions. Under current operations, daily average water temperatures exceed optimal holding temperatures in the summer downstream of the compliance point at IGO where adult CV spring-run Chinook salmon are located annually. Under the PA, water temperatures will likely continue to degrade CV spring-run Chinook salmon holding habitat downstream of the compliance point. Flows will increase and water temperatures will decrease during the fall temperature management under the PA, improving the migratory corridor PBFs for both juvenile and adult CV spring-run Chinook salmon, and CCV steelhead.

Currently, the overall reduction in the frequency and magnitude of flood flows, and static base flows have contributed to the degradation of migratory PBFs for adult and juvenile life stages. Increased flow releases during pulse flows under current operations will provide flow variation, increased turbidity, cover, and additional passage routes. These conditions are expected to improve the freshwater migratory corridor PBFs for CV spring-run Chinook salmon adults and juveniles, and CV steelhead juveniles. Pulse flows for channel maintenance and spring attraction will continue to provide improvement to the migratory corridor.

#### 2.6.4 American River Division

### 2.6.4.1 Effects to Designated Critical Habitat PBFs for ESA-listed Salmonids

The lower American River is designated critical habitat for CCV steelhead. The PBFs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. This analysis on the effects of the PA on steelhead critical habitat is based on information presented in preceding sections regarding its effects to CCV steelhead, and are summarized below as they relate to the PBFs of critical habitat. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure, and condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure, response, risk), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles is likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

Although there is some improvement in the PA, spawning and rearing PBFs in the American River are still expected to be negatively affected by flow and water temperature conditions associated with the PA, as they are under the current operations. Elevated water temperatures can degrade spawning habitat for those CCV steelhead that spawn later in the season, or farther downstream, leading to reduced productivity. There is also a potential for reduced diversity in

life-history timing by truncating the timing and area available for successful spawning. Consequently, reduced suitability of habitat due to elevated water temperatures during some months of the spawning season can result in degradation or depletion of spawning PBFs for salmonid critical habitat.

High flows during flood control operations expected under both the COS and PA scenarios can negatively affect steelhead spawning habitat by mobilizing gravels. Decreased spawning gravel availability during the spawning season can result in degradation or depletion of spawning PBFs for salmonid critical habitat. Spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization occurring at flows of 50,000 cfs or greater (Ayres Associates 2001). Flood frequency analysis for the American River at Fair Oaks gauge shows that, on average, flows will exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years. A flood frequency analysis by National Marine Fisheries Service (2018e) found that in 33 percent of years flows will exceed 30,000 cfs, with 11 percent of years having multiple flow events exceeding 30,000 cfs.

Spawning and rearing habitat in the lower American River is negatively affected by flow fluctuations, which can result in redd dewatering and isolation, fry stranding, and juvenile isolation (see Section 2.5.4.2.2). Additionally, the quality of spawning/incubation and rearing habitat PBFs for CCV steelhead is expected to be reduced by the occurrence of warm water temperatures (see Sections 0 and 2.5.4.1.1). These relatively warm water temperatures also increase susceptibility of juvenile CCV steelhead to predation due to both increased predator abundance and increased digestion and consumption rates of these predators associated with higher water temperature (Vigg and Burley 1991, Vigg et al. 1991).

Freshwater migration corridors also are PBFs of critical habitat. They are located downstream of spawning habitat, allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions for CCV steelhead smolt emigration are expected to be impaired with implementation of the PA, because of exposure to water temperatures that are too warm to allow for successful transformation from parr-to-smolt life stages (see Section 2.5.4.1.2).

Based on the above discussion, the value of spawning, rearing, and migratory habitat PBFs for the conservation of the species are negatively affected as a result of the PA.

### 2.6.5 Bay-Delta Division

Critical habitat impacted by the PA includes the waters of the Sacramento – San Joaquin Delta, which is generally defined as the legal Delta which roughly includes the region of waterways bounded by: the Sacramento River downstream from the I Street Bridge in Sacramento, the San Joaquin River downstream from the Airport Way Bridge near Vernalis, waters bounded on the east approximately by the alignment of I-5, and westwards to nearly the western tip of Chipps Island. This region provides three general habitat types essential to one or more life stages of listed fish, including freshwater rearing sites, freshwater migration corridors, and estuarine areas for rearing and migration. Designated critical habitat exist in the Delta Division for the following species:

- Sacramento River winter-run Chinook salmon
- CV spring-run Chinook salmon

- · CCV steelhead
- sDPS green sturgeon

## 2.6.5.1 Effects to Designated Critical Habitat PBFs for ESA-Listed Salmonids

Critical habitat for winter-run Chinook salmon exists in the main stem Sacramento River from the I Street Bridge in Sacramento to Chipps Island, but also includes the waterways surrounding Kimball Island, Winter Island, and Browns Island within the lower San Joaquin River, which are all contained within the western region of the legal Delta. Winter-run Chinook salmon critical habitat also includes the waters westward of Chipps Island to the Carquinez Bridge including Suisun Bay, Honker and Grizzly bays and the Carquinez Strait, San Pablo Bay, and that portion of San Francisco Bay north of the Bay Bridge and extending to the Golden Gate Bridge. The critical habitat designation in the bays for winter-run Chinook salmon does not include any estuarine sloughs in this region. Designated critical habitat for CV spring-run Chinook salmon exists in the northern Delta but not the San Joaquin River side of the Delta. Waterways include the main stem Sacramento from the I Street Bridge to the western tip of Sherman Island, and the waterways located to the north of the main stem Sacramento River, including Sutter, Steamboat, Miner, Elk, and Elkhorn sloughs, the Cache Slough complex, and the Yolo Bypass. Waterways to the south of the main stem Sacramento River that are designated as CV spring-run critical habitat include Georgiana Slough to its confluence with the Mokelumne River, Threemile Slough to its confluence with the San Joaquin River, and that portion of the DCC between the Sacramento River and Snodgrass Slough. Designated critical habitat for CCV steelhead includes most of the legal Delta, with a few exceptions.

Critical habitat for both CV spring-run Chinook salmon and CCV steelhead was designated concurrently, and as such they share the same PBFs. The PBFs for winter-run Chinook salmon are related and similar to the habitat types of the other listed salmonids, but they were described with more specificity at the time of their designation. The general habitat types that occur within the Bay-Delta action area provide the structure for the assessment of habitat impacts for all salmonids. For each habitat type, and each fish species, the specific PBFs that correspond to ESA-listed critical habitat are identified.

The PBFs of critical habitat in the Bay-Delta region include freshwater rearing areas, freshwater migration corridors, and estuarine areas used for rearing and migration. This analysis on the effects of the PA on critical habitat is based on information presented in preceding sections regarding its effects on listed salmonids, and are summarized below as they relate to the PBFs of critical habitat. As effects to individual fish are intrinsically linked to what life stage is present at the time of the exposure, and condition of the habitat to support that life stage, we use the species effects analysis conclusions (exposure, response, risk), as the foundation for our analysis of effects to critical habitat. For example, as effects of riparian removal on rearing juveniles is likely to result in reduced growth/survival, the effect to critical habitat would be described in terms of the PBFs affected for that life stage, thereby resulting in degraded rearing habitat.

Based on the discussion below, summarized in Table 2.6.5-1, the value of rearing, and migratory habitats for the conservation of the species are negatively affected as a result of the PA.

### 2.6.5.1.1 Freshwater Rearing Habitat for Juveniles

Sacramento River winter-run Chinook salmon PBFs:

- Habitat areas and adequate prey that are not contaminated
- · Riparian habitat that provides for successful juvenile development and survival

CV spring-run Chinook salmon and CCV steelhead PBFs:

Fresh water rearing sites with water quantity and floodplain connectivity to form and
maintain physical habitat conditions and support juvenile growth and mobility; water
quality and forage supporting juvenile development; and natural cover such as shade,
submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation,
large rocks and boulders, side channels, and undercut banks.

Freshwater rearing habitat occurs for all three salmonid species in the main stem of the Sacramento River and the numerous waterways and sloughs comprising the northern Delta. Freshwater rearing habitat occurs in the south Delta waterways for only CCV steelhead. However the quality of this rearing habitat in the Delta is variable, and most of it has been degraded by anthropogenic actions (i.e. levee construction, removal of riparian vegetation, and armoring of shorelines and levees).

Actions related to the PA include the construction of the seasonal south Delta agricultural barriers, which have the potential to degrade water quality by creating impoundments in tidally influenced riverine sections of the south Delta during the period of their installation (~May – November). This can reduce dissolved oxygen through less mixing, and create warmer water temperature conditions due to a reduction in water exchange and increase residence times for water upstream of the barriers. Due to the warmer temperatures and reduced flows, nonnative invasive plants and fish are favored. The change in habitat characteristics favor non-native predators, such as centrarchids, as well as aquatic plants such as Brazilian waterweed (*Egeria densa*) and water hyacinth (*Eichhornia crassippes*). Such conditions reduce the value of the rearing habitat in the affected waterways for listed CCV steelhead migrating through these waterways when the barriers are in place. Construction of the south Delta agricultural barriers does not impact designated critical habitat in other portions of the south delta or north Delta.

Conversely, the potential to expand the period of water transfers to include October and November may enhance rearing conditions in both the northern and southern Delta by increasing flows and improving water quality. Increased flows during this period may improve water temperatures, as well as increasing dissolved oxygen through better mixing of the water column. Both of these effects will improve rearing habitats for listed salmonids. In addition, increased flows in the main stem rivers may also benefit primary and secondary production, which then enhances the forage base for listed salmonids. However, under the PA component to extend the water transfer window an additional 2 months, the potential to increase the level of exports to capture this water increases. Increased exports create conditions that diminish the value of the regional waterways as migratory corridors (see following discussion).

# 2.6.5.1.2 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Sacramento River winter-run Chinook salmon PBFs:

- Adequate river flows for successful downstream transport of juveniles
- Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River

 Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean

CV spring-run Chinook salmon and CCV steelhead PBFs:

 Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

Freshwater migratory corridor critical habitat occurs for all three salmonid species in the main stem of the Sacramento River and the numerous waterways and sloughs comprising the northern Delta. Freshwater migratory corridor critical habitat occurs in the south Delta waterways for only CCV steelhead. The quality of this migratory habitat is variable, and some routes have substantially lower survival rates than other routes. The PA has several elements that will route migrating juvenile listed salmonids into migratory paths that have lower survival rates, or delay or alter migratory behavior which effects transit times.

Within the north Delta, juvenile survival is higher along migratory routes within the main stem of the Sacramento River and, generally, the migratory routes that go through Sutter and Steamboat Sloughs. The PA has the potential to operate the DCC radial gates more frequently than the COS by opening the gates during the fall and early winter. As clarified in the final PA, the DCC openings during December and January will occur only during drought conditions when there are also water quality concerns that could be addressed by opening the DCC gates (see sections 2.5.6.2 and 2.5.5.11.2.2). When the DCC gates are open, it allows for the routing of juvenile listed salmonids into the interior Delta where studies have shown survival to be lower for acoustic tagged study fish (Chinook salmon). Hydrodynamic modeling and studies using acoustic tagged Chinook salmon have also shown downstream effects when the gates are open that increases the vulnerability of fish to routing into the interior Delta or delays in their migrations in the downstream reaches due to interactions with tidal flows within the river channels (see section 2.5.6.2.4). Adults may also be affected by more frequent openings of the DCC gates through false attraction flows. Adult salmonids that are attracted into the Mokelumne River system by Sacramento River water flowing through the open DCC gates may become trapped behind the gates when they close. Migration upstream will be delayed until these fish drop back down into the lower Mokelumne River and pass upstream through an alternate route (i.e., Georgiana Slough) to the main stem Sacramento River.

Delays in migration for juvenile salmonids, although slight, are also anticipated from the operations of the NBA/BSPP and CCWD Rock Slough intakes due to the diversion of water from dead end sloughs (see Sections 2.5.5.4 and 2.5.5.5). Much more extensive delays and changes in routing are expected from the operations of the SWP and CVP export facilities in the south Delta due to the substantial alterations in regional hydrodynamics (i.e., reverse flows in main channels) (see Section 2.5.5.8). Alterations in migratory routing and delays in migration due to reverse flows and longer transit times/ transit distances are expected to diminish the value of the regional waterways to act as migratory corridors. Longer transit times and distances, as well as migratory movements through lower quality migratory routes are expected to reduce survival. Adult listed salmonids are also expected to have migratory delays due to the hydrodynamic alterations. Flow and olfactory cues will be altered by the flow of river waters towards the export facilities rather than downstream towards the western Delta.

Alterations in flow, and the creation of migratory barriers are anticipated from the installation and operation of the south Delta agricultural barriers for both adult and juvenile CCV steelhead. Acoustic tagged juvenile steelhead and Chinook salmon were shown to be delayed in passing downstream over the weir crests of the barriers or through the tidally operated culverts penetrating the barriers. Fish milled above the locations of the barriers where reduction in survival was hypothesized to be related to greater exposure to predators upstream of the barriers. This will impact the functioning of the freshwater migratory corridors of the designated critical habitat for CCV steelhead in the south Delta. Delays in upstream migration of adult steelhead are also expected as the barriers will create impediments to the movement of fish through the affected channels. Passage over the weirs, even with the required notches and removal of flashboards in the fall, will be related to depth of water passing over the weir crest. Water depth is greatest during the top of the flood tide and just after it turns to the ebbing tide following slack tide. Thus passage is limited to only those periods of time when sufficient water depth over the weirs exist.

There are aspects of the PA that may improve migratory corridor function, namely the extension of the water transfer window. Since transfers may originate from either the Sacramento River or San Joaquin River basins, designated critical habitat for all three listed salmonid species may be affected (see above description of the locations of designated critical habitat within the Delta region). As discussed above, increased flows associated with the releases of transfer water will enhance the riverine portions of the Delta by increasing flow velocity within the main channels. This should reduce the necessary transit time for any juvenile listed salmonids required to move through a given reach of river. The benefits to migratory corridors will be related to the volume and duration of any water transfers. More volume or prolonged duration of water releases are believed to provide better migratory conditions than shorter or smaller volumes of releases. Increased flows with concurrent increases in water velocity and reductions in transit time will reduce the exposure of juvenile listed salmonids to predators and should therefore reduce predation and increase survival. For adult salmonids moving upstream (predominately steelhead due to the timing of the transfer window) increased flows should stimulate upstream migration into the upper rivers from the Delta as well as providing better olfactory cues to upstream regions. However, while the increased flows due to water transfers will benefit listed salmonids, the concurrent export of this water will create the altered hydrodynamics discussed previously. This offsetting effect will be greatest for the designated CCV steelhead critical habitat in the San Joaquin River side of the Delta.

# 2.6.5.1.3 Estuarine Habitat for Rearing and Migration of Juvenile Listed Salmonids and Upstream Migrating Adults

Sacramento River winter-run Chinook salmon PBFs:

- Habitat areas and adequate prey that are not contaminated
- Riparian habitat that provides for successful juvenile development and survival
- Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River
- Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean

CV spring-run Chinook salmon and CCV steelhead PBFs:

 Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Estuaries are the zone in which fresh water from upstream riverine sources mixes with the full salinity of marine water. An estuary is a partially enclosed body of water, and its surrounding coastal habitats, where saltwater from the ocean mixes with fresh water from rivers or streams. In fresh water the concentration of salts, or salinity, is nearly zero. The salinity of water in the ocean averages about 35 parts per thousand (ppt). The mixture of seawater and fresh water in estuaries is called brackish water and its salinity can range from 0.5 to 35 ppt. A salinity (in ppt) of 0.5 is approximately equivalent to 1,000 micro Siemens conductivity at 22°C. Those waters of the Delta upstream of Rio Vista on the Sacramento River, and Jersey Point on the San Joaquin River would typically have salinities of 0.5 ppt or lower based on the measured conductivity at almost all times. River inflow and tides will influence where the boundary of 0.5 ppt salinity will be found. Thus, the estuarine regions of the Delta would include designated critical habitat for winter-run and spring-run Chinook salmon and CCV steelhead downstream from approximately Rio Vista to approximately the junction of the Sacramento and San Joaquin Rivers. Estuarine critical habitat for CCV steelhead would extend from approximately Jersey Point downstream to Chipps Island on the San Joaquin River side of the Delta. Critical habitat for winter-run Chinook salmon, and CCV steelhead would also include the western portions of the Delta, and the waterways from Chipps Island to the Golden Gate Bridge as described previously.

Within the Bay/ Delta region, the PA will affect the PBFs of critical habitat in only a few instances. Increased river inflows due to upstream reservoir releases can move the extent of salinity intrusion farther to the west, theoretically increasing the area of productive mixing in the western Delta between fresh and saline waters. This will lead to increasing amounts of primary and secondary productivity, which in turn enhances the forage base for juvenile salmonids. The PBFs for winter-run Chinook salmon include "habitat areas and adequate prey that are not contaminated." Likewise, the PBFs for spring-run Chinook salmon and CCV steelhead include a provision for "juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation." The increase in primary and secondary productivity associated with a mixing zone in the western portion of the Delta will meet these PBFs.

Listed winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead could be affected by the operation of the SMSCG, with the gates potentially delaying upstream-migrating adults that have entered Montezuma Slough and are seeking to exit the slough at its eastward end. Adult winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead that do not continue upstream past the SMSCG through the open boat lock gates are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they will likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker Bays. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 17 to 69 days of annual operation, which could also delay juvenile winter-run and CV spring-run Chinook salmon and CCV steelhead migration. However, these changes in water flow will be limited to the flood portion of the tidal cycle and will

generally be limited to a few days during each periodic operational episode. Overall, the shortterm changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG are expected to cause a minor impact to this PBF for both migrating juveniles and adults of these listed salmonids. The operations of the SMSCG may impact designated critical habitat estuarine PBFs for CCV steelhead or spring-run Chinook salmon migration due to the gates being located in waters, which although not specifically identified as critical habitat for these species, do lie within the area of San Francisco -San Pablo- Suisun Bay as defined by the perimeter of the water body as displayed on a 1:24,000 scale topographic map or by the extreme high water mark, whichever is greater. Thus, actual migration may be affected for individual fish in these waterways. Proposed operations of the SMSCG during the summer months (June – September) for up to 60 days in below-normal and above-normal water years (Sacramento Valley Index) to improve habitat for Delta smelt in the Suisun Marsh waterways will not impact critical habitat for winter-run as any changes to the habitat are not permanent and it is not expected that any adult or juvenile winter-run will be present during this time period to be exposed to the gate operations. In contrast, some adult CCV steelhead may be affected as they migrate upriver during the summer and early fall. Adult CV spring-run are unlikely to be affected during the summer gate operations.

The PA also indicates that the remaining 6,000 acres of tidal habitat restoration in the Delta of the original 8,000 acres committed to by DWR will be completed under the PA. Construction of the tidal habitat restoration areas may create temporary conditions that degrade designated critical habitat for all three listed species in the estuarine areas. Reclamation has indicated in its BA for the consultation (Reclamation 2019) that there may be:

"temporary loss of aquatic and riparian habitat leading to increased predation, increased water temperature, and reduced food availability; degraded water quality from contaminant discharge by heavy equipment and soils, and increased discharges of suspended solids and turbidity, leading to direct toxicological impacts on fish health/performance, indirect impairment of aquatic ecosystem productivity, loss of aquatic vegetation providing physical shelter, and reduced foraging ability caused by decreased visibility; impediments and delay in migration caused by elevated noise levels from machinery; and direct injury or mortality from in-water equipment strikes or isolation/stranding within dewatered cofferdams."

Such actions would temporarily degrade the functioning of the estuarine critical habitat for listed salmonids by reducing available forage base, introducing contaminants to the aquatic system, and interfering with unimpeded access for both juveniles and adults to move through the estuarine system. The scope of this effect is not currently certain, since the restoration project was not fully described, including all locations of restoration sites and the schedule for work to be completed. It is expected though, that in the future, the restored tidal habitat will be a net benefit and provide additional refuge and rearing habitat for juvenile listed salmonids, additional forage base, and better growth and survival for fish utilizing these habitats.

# 2.6.5.1.4 Summary of Effects to Designated Critical Habitat PBFs for ESA-Listed Salmonids

Table 2.6.5-1. Summary of responses of Listed Salmonids to the proposed action and probable changes in Designated Critical Habitat PBFs in the Delta.

Action Component	PBF Affected	Species	Response	Probable Change in PBF
Water transfer window extension	Freshwater rearing sites	WRCS CV SRCS CCV SH	1) Improved in-river flow conditions may improve water temperature conditions in the mainstem Sacramento River. 2) Improved flow conditions may improve dissolved oxygen conditions through improved mixing of water column and water surface - air interface. 3) Improved water quality in fall may improve primary and secondary productivity benefitting forage base.	Improved quality of rearing habitat for WRCS, CV SRCS, and CCV SH
Water transfer window extension	Freshwater migratory corridor	WRCS CV SRCS CCV SH	Enhanced flows from water transfers can benefit juvenile listed salmonids in fall (October and November) migrating downstream by decreasing travel times, increasing the length of riverine reaches, and muting downstream tidal effects. Increased flows can also stimulate upstream migration of CCV SH in fall.	Improved quality of freshwater migratory habitat for WRCS, CV SRCS, and CCV SH
North Bay Aqueduct/ Barker Slough Pumping Plant	Freshwater migratory corridor	WRCS CV SRCS CCV SH	Operations of NBA/ Barker Slough Pumping Plant may delay migration of juveniles due to alterations to flow patterns created by the export of water and thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.	Reduced quality of migratory habitat for juveniles.

Action Component	PBF Affected	Species	Response	Probable Change in PBF
DCC Gate Operations	Freshwater migratory corridor	WRCS CV SRCS CCV SH	1) Access to the interior Delta through open DCC gates reduces the survival of migrating juveniles, reduces the value of the mainstem as a suitable migratory corridor. 2) Operations of the DCC gates can alter the extent of tidal influence in the river reaches downstream of the DCC location, delaying migration or re-routing juveniles into alternate migratory routes with lower survival. 3) Operations of the DCC gates reduces the upstream migratory function of the mainstem Sacramento River to adults, enhances straying and migratory delays. 4) Open DCC gates allows access to habitat under the influence of the SWP and CVP export actions.	Reduced quality of migratory habitat for adults and juveniles; lesser effect in final PA due to revised DCC operations in December-January.
Contra Costa Water District/ Rock Slough	Freshwater migratory corridor	CCV SH	Operations of CCWD/ Rock Slough may delay migration of juveniles due to alterations to flow patterns created by the export of water and thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.	Reduced quality of migratory habitat for juveniles.
CVP and SWP Export Facilities	Freshwater migratory corridor	CCV SH	Increased exports by the CVP and SWP Export facilities create hydrodynamic conditions in the channels of the South Delta that impede steelhead migration	Reduced quality of migratory habitat for juveniles, lesser effect in final PA due to revised loss thresholds.

Action Component	PBF Affected	Species	Response	Probable Change in PBF
			downstream to the ocean (reverse flows),	
South Delta Agricultural Barriers	Freshwater rearing sites	CCV SH	Operations of the south Delta agricultural barriers will reduce flow velocities and increase water residence time within channels of the south Delta, degrading water quality and potentially increasing water temperatures.	Reduced quality of rearing habitat for juveniles
South Delta Agricultural Barriers	Freshwater migratory corridor	CCV SH	Construction of the South Delta agricultural barriers create 1) barriers to the downstream movement of juvenile steelhead and upstream movement of adult steelhead into the San Joaquin River basin; 2) decreases in water quality, including lower dissolved oxygen and suitable water temperatures that impair physiology; 3) creates habitat with excessive predation risk.	Reduced quality of migratory habitat for juveniles and adult CCV SH.
Fall Delta Smelt Habitat	Freshwater rearing sites	WRCS, CV SRCS, CCV SH	Release of additional water from upstream to augment Delta outflow will improve water quality, and enhance forage prey populations that support juvenile salmonid development.	Minor enhancement of quality of rearing habitat
Fall Delta Smelt Habitat	Freshwater migratory corridor	WRCS, CV SRCS, CCV SH	Release of additional water from upstream to augment Delta outflow will improve water quality and conditions supporting the mobility and survival of adult and juvenile salmonids	Minor enhancement of quality of migratory corridor habitat

Action Component	PBF Affected	Species	Response	Probable Change in PBF
Fall Delta Smelt Habitat	Estuarine areas	WRCS, CV SRCS, CCV SH	Release of upstream water will enhance 1) water quality, water quantity, and provide suitable salinity conditions supporting juvenile and adult salmonid physiological transitions; and 2) enhance juvenile and adult forage prey that will support growth and maturation. Operations of the SMSCG will create temporary obstructions to free migration and potentially create predator habitat.	Minor benefit for water quality improvement and forage base, minor deficit for obstruction of passage and enhanced predator risks for estuarine areas.
Sacramento Deep Water Ship Channel Food Study	Freshwater migratory Corridor	WRCS, CV SRCS, CCV SH	Potential improvement of primary and secondary productivity in Sacramento River downstream of the artificial DWSC. Possible resuspension of contaminated sediments. Migratory blockage created by closed gate.	Minor benefit for improved forage base, minor deficit for contaminants in the water body, migratory obstructions reducing quality of the migratory corridor.
North Delta Food Subsidies / Colusa Basin Drain Food Subsidy Studies	Freshwater migratory corridors	WRCS, CV SRCS, CCV SH	Potential degradation of water quality due to contaminants and nutrients related to agricultural practices that impact adult and juvenile mobility and survival.  Potential benefit to primary and secondary productivity that enhances forage base, improving physiological status, survival, and mobility	Minor benefit for improved forage base, minor deficit for contaminants and nutrients in the quality of the migratory corridor.
Suisun Marsh Roaring River Distribution	Estuarine areas	WRCS, CV SRCS, CCV SH	Temporary migratory obstructions due to SMSCG operations. Increase in juvenile and adult forage base due to nutrient infusions,	Minor deficit due to migratory obstructions and minor benefit due to enhanced

Action Component	PBF Affected	Species	Response	Probable Change in PBF
System Food Subsidy Studies			resulting in growth and maturation	forage prey base in the estuarine areas.
Tidal Habitat Restoration	Estuarine areas	WRCS, CV SRCS, CCV SH	Temporary degradation of water quality due to restoration construction actions. Temporary physical and behavioral disturbances creating migratory obstructions. Long term improvement in water quality, holding and rearing areas, forage base, and better growth and survival.	Early degradation of estuarine habitat due to restoration activities, followed by potential large improvements in estuarine habitat quality.

### 2.6.5.2 Effects to sDPS Green Sturgeon Critical Habitat

Members of the sDPS green sturgeon population utilize the aquatic habitat of the Delta for rearing, resting and holding, foraging, and migration. Critical habitat has been designated to include all of the waters of the legal Delta with a few exceptions and the waters of Suisun Bay, San Pablo Bay, and north and south San Francisco Bays up to the highest high tide line.

Based on the discussion below and summarized in Table 2.6.5-2, the value of rearing, and migratory habitats for the conservation of the species are negatively affected as a result of the PA.

#### 2.6.5.2.1 Freshwater Riverine Systems

The following PBFs apply to the designated critical habitat for the sDPS of green sturgeon in freshwater riverine systems of the Delta:

- Food resources
- Substrate type or size
- Water Flow
- Water quality
- Migratory corridor
- Water Depth
- Sediment quality

As described previously for listed salmonids, actions related to the PA include the construction of the seasonal south Delta agricultural barriers, which have the potential to degrade water quality by creating impoundments in tidally influenced riverine sections of the south Delta

during the period of their installation (~May – November). The barriers also create impediments to migratory corridors through the channels of the South Delta, including primarily Old River and Grant Line Canal. Middle River is also blocked by the agricultural barriers, but the water depth and habitat present is unlikely to be suitable for green sturgeon even when the barrier is absent. When the barriers are constructed, they begin to slow the flow of water through the impacted channels, and reduce velocities and turnover of the water mass. This leads to increasing thermal load for the impounded waters due to warm air temperatures and solar irradiation. As a result of this, water quality tends to decline, particularly dissolved oxygen levels. Low dissolved oxygen coupled with increasing water temperatures create inhospitable habitat conditions for sDPS green sturgeon. However, the overall impact to sDPS green sturgeon critical habitat is considered to be low due to the low proportion of the green sturgeon population found in the waterways of the South Delta.

Operations of the DCC gates in the north Delta can lead to potentially adverse migratory corridor conditions for juvenile and adult sDPS green sturgeon. However, very little is known regarding the utilization of different habitat types by either adult or juvenile sDPS green sturgeon in the Delta. Since juvenile sDPS green sturgeon spend several months to years rearing in the Delta, diversion into the Delta interior may not adversely impact the survival of individual fish. These waters are accessible to juvenile sDPS green sturgeon from the San Joaquin River via the channels of the Mokelumne River system and may not materially increase migratory transit time or distance during their prolonged rearing phase. Without information regarding habitat use and preferences, and survival of juvenile sDPS green sturgeon through the interior Delta routes, there is insufficient information to conclude that this alternative route is worse than remaining in the main stem of the Sacramento River. Adults migrating downstream after spawning may pass through the DCC, but migration through the Mokelumne River system and into the lower San Joaquin River and then to the western Delta via the main stem of that river may not adversely affect these individual fish. For adult sDPS green sturgeon migrating upstream to spawn, open DCC gates may provide a false attraction cue to the Sacramento River basin via the San Joaquin River and Mokelumne River systems. Fish may be delayed if gates are subsequently closed, forcing them to back track to regain access to the Sacramento River. It is not known whether this would create an adverse effect to the spawning ability and success of impacted fish. The impact of the DCC gate operations on sDPS green sturgeon critical habitat is considered to be low. Given the extended period of time that juvenile and adult sDPS green sturgeon may spend in the Delta region before migrating to the marine environment, the changes in migratory routing and transit times may not materially impact the functioning of the Sacramento River as a migratory route.

Operations of the NBA/ BSPP and the CCWD/ Rock Slough diversion may create temporary delays in migration through the diversion of water from the dead end sloughs they are located on. There is the potential that individual fish in waterways adjacent to the facilities may experience temporary interruptions in their movements due to the slight reverse flow towards the export location caused by the diversion of water. As explained in the previous paragraph, juvenile and adult sDPS green sturgeon may spend extended periods of time in the Delta and the impact of a short term delay is unknown. The magnitude of the effects on the functioning of the critical habitat as a migratory corridor is therefore considered to be low from the operations of these two export facilities.

In contrast, the effects of the SWP and CVP exports in the south Delta are much larger. The volume of water exported is substantially greater than that which is exported by the CCWD and BSPP operations. Flows in the south Delta waterways that are part of the designated critical habitat for green sturgeon are typically altered to the point that net flows move upriver towards the export facilities from downstream locations (reverse flows). The extent of the footprint of these export effects is variable. In dry conditions, with little inflow to the Delta from the Sacramento and San Joaquin river basins, the effects of the SWP and CVP diversions can extend a considerable distance and may impact waterways as far downstream on the San Joaquin River as Jersey Point through the combined effects of tidal forcing and net reverse flows. In wetter conditions, with substantially higher inflows to the Delta, this impact is muted, particularly if the San Joaquin River has high flows. Under reverse flow conditions, fish migration is not only delayed, but individual fish may be more likely to be entrained into the export facilities. At the CVP, small fish may enter the fish salvage process, while larger fish are screened out of the facilities by the trash rack. At the SWP, both adult and juvenile fish are entrained into the CCFB when the radial gates are open and may be detained in this waterbody for a considerable amount of time. Smaller fish may be salvaged at the SDFPF, as they can pass through the trash racks, while larger fish are prevented from entering the salvage process due to the narrow spacing of the metal bars on the trash rack screen. Larger fish can only escape the CCFB if they swim back out of the radial gates and reenter the Delta via West Canal and Old River. Although the physical effects related to the operations of the SWP and CVP are large, the impacts to the migratory corridor element of the PBFs is considered medium due to the distribution of sDPS green sturgeon in the Delta. Furthermore, the final PA has loss thresholds for listed salmonids that have the potential to reduce exports if exceeded, thus reducing the potential magnitude of hydrodynamic effects in channels leading to the export facilities when implemented.

There are several actions related to the PA that occur within the SWP and CVP facilities or CCFB that could affect sDPS green sturgeon directly or the aquatic habitat they are found in; such as aquatic weed control or predator removal actions. However, these areas are outside the limits of designated critical habitat for sDPS green sturgeon and will not be discussed further.

#### 2.6.5.2.2 Estuarine Systems

The following PBFs apply to the designated critical habitat for sDPS green sturgeon in estuarine systems of the Delta:

- Food resources
- Substrate type or size
- Water Flow
- Water quality
- · Migratory corridor
- Water Depth
- Sediment quality

The same definition of estuarine areas that applied to listed salmonids will be used for sDPS green sturgeon. Estuarine areas are those water with salinities ranging from 0.5 ppt to full sea water salinity (35 ppt). Those waters of the Delta upstream of Rio Vista on the Sacramento River, and Jersey Point on the San Joaquin River would typically have salinities of 0.5 ppt or lower based on the measured conductivity at almost all times. River inflow and tides will

influence where the boundary of 0.5 ppt salinity will be found. The estuarine regions of the Delta would include those portions of the Delta downstream of approximately Rio Vista on the Sacramento River, and Jersey Point on the San Joaquin River, and all waters to the west including Suisun Bay, Honker Bay, Grizzly Bay, Suisun Marsh, San Pablo Bay, north and south San Francisco Bay and all tidally influenced slough and channels up to the mean higher high tide line in those waterbodies.

Few actions described for the PA will impact estuarine critical habitat PBFs for sDPS green sturgeon. Increased outflow from reservoirs will benefit sDPS green sturgeon by increasing the area of high productivity created by moving the mixing zone farther to the west into the western Delta and Suisun Bay. However since green sturgeon are capable of tolerating a wide variety of salinities as either juveniles, sub-adults, or adults, and foraging on a wide variety of food sources including most benthic invertebrates as well as several species of fish found in the Delta and estuarine areas, they are not limited to the area of increased mixing for foraging. Higher flows would enhance upstream spawning migrations for adults in the winter and spring, allowing fish to orient to the flow cues. However flows should be sufficient to allow this behavior under the PA in most circumstances.

Listed sDPS green sturgeon could be affected by the operation of the SMSCG, with the gates potentially delaying upstream-migrating adult green sturgeon that have entered the Montezuma Slough migratory route and are seeking to exit the slough at its eastward end. Adult green sturgeon that do not continue upstream past the SMSCG through the open boat lock gates are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they will likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker Bays. Post-spawn adult sDPS green sturgeon migrating downstream may have their entrance into Montezuma Slough blocked or impeded by SMSCG operations. However, any fish that is blocked or impeded from using this route can easily access Suisun Bay through the main stem Sacramento River, thus little if any adverse effects to migratory routing are anticipated.

The impacts to estuarine critical habitat for sDPS green sturgeon related to the restoration of 6,000 acres of tidal habitat will be the same as already described for listed salmonids. It is anticipated that there will be temporary adverse impacts to the functioning of estuarine critical habitat related to degradation of water quality, release of contaminants, and reduction in local forage food resources during construction. Long term benefits will include an increase in the production of food resources associated with tidal habitat and marshes, and the improvement in water quality conditions due to the functioning of the tidal habitat and any associated fringing marshes to remove contaminants from the system.

## 2.6.5.2.3 Summary of Effects to sDPS Green Sturgeon Critical Habitat

Table 2.6.5-2. Summary of responses of listed sDPS green sturgeon to the proposed action and probable changes in Designated Critical Habitat PBFs in the Delta.

Action	PBF Affected	Response	Probable Change in PBF
Water transfer window extension	Freshwater Riverine Habitat	Additional in-river flow may improve water quality conditions (i.e. temperatures and dissolved oxygen) in the mainstem Sacramento River. 2) Improved flow conditions may improve migratory corridor conditions. 3) Improved water quality in fall may improve primary and secondary productivity, benefitting food resources.	Improved quality habitat of freshwater riverine habitat for water quality, migration and food resources
North Bay Aqueduct/ Barker Slough Pumping Plant	Freshwater Riverine Habitat	Operations of NBA/ Barker Slough Pumping Plant may delay movements of juveniles due to alterations to flow patterns created by the export of water and thereby impeding the mobility of juvenile sDPS green sturgeon.	Minimal reduced quality of migratory corridor for juveniles.
DCC Gate Operations	Freshwater Riverine Habitat	1) Access to the interior Delta through open DCC gates alters the function of the mainstem Sacramento River as a suitable migratory corridor to the western Delta. 2) Operations of the DCC gates can alter the extent of tidal influence in the river reaches downstream of the DCC location, delaying migration or re-routing juveniles into alternate migratory routes with lower habitat quality. 3) Operations of the DCC gates reduces the upstream migratory function of the mainstem Sacramento River to adults, enhances straying and migratory	Reduced quality of migratory habitat for adults and juveniles; lesser effect in final PA due to revised DCC operations in December-January.

Action	PBF	Response	Probable Change in PBF
Component	Affected		
•		delays. 4) Open DCC gates allows access to habitat under the influence of the SWP and CVP export actions.	
Contra Costa Water District/ Rock Slough	Freshwater Riverine Habitat	Operations of CCWD/ Rock Slough may alter the movements of juveniles due to alterations to flow patterns created by the export of water and thereby impeding the mobility of juvenile sDPS green sturgeon.	Reduced quality of migratory habitat for juveniles.
CVP and SWP Export Facilities	Freshwater Riverine Habitat	Increased exports by the CVP and SWP Export facilities create hydrodynamic conditions in the channels of the South Delta that impede or alter sDPS green sturgeon movements in the region's migratory corridors (reverse flows),	Reduced quality of migratory habitat for juveniles, lesser effect in final PA due to revised loss thresholds.
South Delta Agricultural Barriers	Freshwater Riverine Habitat	Operations of the south Delta agricultural barriers will reduce flow velocities and increase water residence time within channels of the south Delta, degrading water quality and potentially increasing water temperatures. Construction of the South Delta agricultural barriers creates barriers to the movements of adult and juvenile sDPS green sturgeon within the South Delta waterways containing the barriers;	Reduced quality of freshwater riverine habitat for water flow, water quality, and as a migratory corridor

Action	PBF	Response	Probable Change in PBF
Component	Affected		
Fall Delta Smelt Habitat	Freshwater Riverine Habitat	Release of additional water from upstream to augment Delta outflow will improve water quality, and enhance forage prey populations that support juvenile and adult sturgeon. Release of additional water from upstream to augment Delta outflow will improve flow conditions supporting the mobility and survival of adult and juvenile sDPS green sturgeon	Minor enhancement in the quality of the freshwater riverine habitat
Fall Delta Smelt Habitat	Estuarine areas	Release of upstream water will enhance 1) water quality, water quantity, and 2) enhance juvenile and adult forage prey that will support growth and maturation. Operations of the SMSCG will create temporary obstructions to free migration.	Minor benefit for water quality improvement and forage base, minor deficit for obstruction of passage for estuarine areas.
Sacramento Deep Water Ship Channel Food Study	Freshwater Riverine Habitat	Potential improvement of primary and secondary productivity in Sacramento River downstream of the artificial DWSC. Possible resuspension of contaminated sediments entering downstream areas designated as critical habitat for sDPS green sturgeon. Migratory blockage created by closed boat lock gate after periods of access through an open gate (upstream migrants cued by false attraction flows).	Minor benefit for improved forage base, minor deficit for contaminants in the water body, migratory obstructions reducing quality of the migratory corridor.
North Delta Food Subsidies / Colusa Basin Drain Food	Freshwater Riverine Habitat	Potential degradation of water quality due to contaminants and nutrients related to agricultural practices that impact adult and juvenile mobility and survival. Potential benefit to primary and secondary productivity that	Minor benefit for improved forage base, minor deficit for contaminants and nutrients in the quality of the freshwater riverine habitat.

Action	PBF	Response	Probable Change in PBF
Component	Affected		
Subsidy Studies		enhances forage base, improving physiological status, survival, and mobility.	
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Estuarine areas	Temporary migratory obstructions due to SMSCG operations. Increase in juvenile and adult forage base due to nutrient infusions, resulting in growth and maturation	Minor deficit due to migratory obstructions and minor benefit due to enhanced forage prey base in the estuarine areas.
Tidal Habitat Restoration	Estuarine areas	Temporary degradation of water quality due to restoration construction actions. Temporary physical and behavioral disturbances creating migratory obstructions. Long term improvement in water quality, holding and rearing areas, forage base, and better growth and survival.	Early degradation of estuarine habitat due to restoration activities, followed by potential large improvements in estuarine habitat quality.

#### 2.6.6 Stanislaus River (East Side Division)

The only designated critical habitat for ESA-listed salmonids in the Stanislaus River is for CCV steelhead, which has been designated up to Goodwin Dam.

The PBFs of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. This analysis on the effects of the PA on CCV steelhead critical habitat is based on information presented in preceding sections regarding its effects on CCV steelhead, and are summarized below as they relate to the PBFs of critical habitat.

#### 2.6.6.1 Habitat for Spawning Adults, Incubation of Eggs, and Rearing for Fry

CCV steelhead spawning habitat on the Stanislaus River is negatively affected by East Side Division operations in two key categories: (1) flow releases may not maintain appropriate temperatures for spawning and egg incubation, particularly in April and May, and (2) flow releases do not support geomorphic processes that would remove fine sediment from spawning gravels and maintain interstitial flows to attract spawners and allow egg incubation.

Monthly average water temperatures at Orange Blossom Bridge exceed the EPA-recommended criterion for CCV steelhead spawning and egg incubation (55°F) in the warmest 20 percent of

years in March and April, 40 percent of years in May, and 80 percent of years in June (see Table 2.5.6-8 and Section 2.5.6.1.5.1). CCV steelhead that spawn later in the season, or farther downstream will have reduced or even failed reproductive success, leading to reduced productivity and also reduce diversity in life-history timing by truncating the timing and area available for successful spawning.

Since the construction of New Melones Dam, channel-mobilizing flows of 5,000 cfs have increased in return interval from 1.5 years to over 5 years. Overbank flows are critical for redistributing fine sediments out of spawning beds and onto the floodplain terrace. Current operations have also caused channel incision of up to 1-3 feet since the construction of New Melones Dam. Channel incision further increases the flows needed to obtain overbank flow and decreases the likelihood of occurrence. Without sufficient flows for geomorphic processes to manage fine sediment deposition in spawning gravels, spawning beds will be increasingly choked with sediment and unsuitable for spawning. Pebble counts and sediment size analysis of spawning areas have shown an increase in sand and fine material in spawning beds since construction of New Melones Dam (Kondolf et al. 2001, Mesick 2001). Most non-enhanced riffles had sufficient fine material to impair egg incubation and survival.

Lack of flow fluctuation and channel forming flows has also resulted in the stabilization of gravel bars by thick riparian vegetation at the river edges. Lack of scouring prevents mobilization of spawnable material to refresh degraded riffles. Proposed operations will continue this degradation of spawning habitat conditions.

The conservation measure committing to 4,500 tons of gravel augmentation per year, to the extent achieved, will help to replenish spawning gravels in the system.

#### 2.6.6.2 Freshwater Rearing Habitat for Juveniles

The freshwater rearing sites PBF includes water quantity and floodplain connectivity to support juvenile growth and mobility, and water quality and forage to support juvenile development. Operations under the PA extremely limit peak flows in the hydrograph, which limits overbank flow to maintain floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility. As mentioned above, channel-mobilizing flows of 5,000 cfs have increased from a return interval of 1.5 years to over 5 years post construction of New Melones Dam. Lack of flow fluctuation and channel forming flows have also resulted in the stabilization of gravel bars by thick riparian vegetation at the river edges. Lack of scouring prevents introduction of large woody debris (LWD), which provides cover, nutrients and habitat complexity, including undercut banks and side channels. Proposed operations will continue this degradation of rearing habitat conditions.

The conservation measure committing to 4,500 tons of gravel augmentation per year, to the extent achieved, will help to support rearing in the system, as young salmon and young and yearling trout are found in significantly higher densities in sites where gravel has been placed in the river to create riffle habitat.

The conservation measure committing to 50 acres of rearing habitat adjacent to the Stanislaus River by 2030, to the extent achieved, will help to augment rearing opportunities in the system.

## 2.6.6.3 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Under proposed operations, the freshwater migration corridors on the Stanislaus River will continue to require juvenile CCV steelhead to pass through predator-rich abandoned mining pits, incised channels that limit channel complexity, and water temperatures that may be lethal or sublethal.

Channel incision resulting from operations post New Melones Dam construction has produced overhanging large wood and river edge aquatic vegetation, but the lack of scouring and channel forming flows has effectively channelized and simplified the corridor. The variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner has been limited by operational conditions. Obstruction of access to historic spawning and rearing habitat requires CCV steelhead to utilize these freshwater migration corridors at times that may not be optimal with respect to temperature, forage availability, and exposure to predators.

The conservation measure committing to 50 acres of rearing habitat adjacent to the Stanislaus River by 2030, to the extent achieved, will help to provide diversified habitats along the Stanislaus River for migrating CCV steelhead.

#### 2.6.7 San Joaquin River (East Side Division)

Consistent with Section 2.5.7 in the Effects to Species, the analysis in this section is limited in geographic extent to the San Joaquin River from the confluence with the Stanislaus River downstream past Vernalis to approximately Mossdale. Designated critical habitat exists in this reach of the San Joaquin River for CCV steelhead and from Vernalis to Mossdale for sDPS green sturgeon.

#### 2.6.7.1 Effects to Designated Critical Habitat PBFs for CCV Steelhead

The only designated critical habitat for ESA-listed salmonids in the San Joaquin River upstream of Mossdale to the confluence with the Stanislaus River is for CCV steelhead.

The PBFs of critical habitat in this reach of the San Joaquin River include freshwater rearing areas, and freshwater migration corridors. This analysis of the PA effects on CCV steelhead critical habitat is based on information presented in the preceding section regarding its effects on CCV steelhead, and are summarized below as they relate to the PBFs of critical habitat.

Based on the discussion below, the value of rearing, and migratory habitats for the conservation of the species are negatively affected as a result of the PA.

#### 2.6.7.1.1 Freshwater Rearing Habitat for Juveniles

Operations under the PA do not allow for overbank flow to maintain floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility. Lack of flow fluctuation and channel forming flows has reduced habitat complexity, including undercut banks and side channels. Proposed operations will continue this degradation of rearing habitat conditions.

### 2.6.7.1.2 Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults

Under proposed operations the freshwater migration corridors on this reach of the San Joaquin River will continue to require juvenile CCV steelhead to pass through a channelized river without the historical variety of habitats that allowed migrating salmonids to avoid high flows, avoid predators, and reach the ocean in a timely manner. CCV steelhead will often navigate these freshwater migration corridors at times that may not be optimal with respect to water temperature. Therefore, the value of the freshwater migration corridors PBF for the conservation of the species, will continue to be reduced with the implementation of the PA.

### 2.6.7.2 Effects to sDPS Green Sturgeon Critical Habitat

Southern DPS green sturgeon are known to occasionally be present in this stretch of the San Joaquin River. There is no evidence of sDPS green sturgeon spawning in the lower San Joaquin River, so the PBFs most associated with spawning (substrate type or size, water flow, water quality) are not considered in the context of spawning or egg incubation. The anticipated impacts to sDPS green sturgeon freshwater rearing and migratory habitat are similar to those discussed for salmonids in Section 2.6.7.1.1 and Section 2.6.7.1.2. In brief, reduced habitat complexity and springtime flows and warm water temperatures will continue under the PA and is expected to degrade the value of the habitat with respect to the following PBFs: food resources, water flow and water quality, and migratory corridor, for the conservation of the species.

### 2.7 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 2007). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

### 2.7.1 Unscreened Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the California Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, their tributaries, and the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile listed anadromous species (Mussen et al. 2013, Mussen et al. 2014b). In 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). More recent data show that over 95 percent of the now over 3,700 water diversions on the Sacramento and

San Joaquin rivers and their tributaries, and in the Delta, remain unscreened (CalFish 2019). The impacts from unscreened water diversions have improved due to the Anadromous Fish Screen AFSP, part of CVPIA, as well as DWR's fish screening program (Meier 2013). While private irrigation diversions in the Delta are mostly unscreened, the total amount of water diverted onto Delta farms has remained stable for decades (Culberson et al. 2008). A study of a dozen unscreened diversions in the Sacramento River, all relatively deep in the channel, reported low entrainment for listed salmonids and steelhead (Vogel 2013).

### 2.7.2 Agricultural Practices

Agricultural practices may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels flowing into the action area, including the Sacramento River, Stanislaus River, San Joaquin River, and Delta. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed fish species by increasing erosion and sedimentation. These practices introduce nitrogen, ammonia, and other nutrients into the watershed, which then flow into receiving waters (Lehman et al. 2014). Ammonia introduction from agricultural activities can be additive with much larger sources, such as wastewater treatment discharges, the effects of which are further discussed in section 2.7.3.

Salmonid and sturgeon exposure to contaminants is inherent in the Delta, ranging in the degree of effects. Stormwater and irrigation discharges related to agricultural activities contain numerous pesticides, herbicides, and other contaminants that may disrupt various physiological mechanisms and negatively affect reproductive success and survival rates of listed anadromous fish (Dubrovsky 1998, Scott and Sloman 2004, Whitehead et al. 2004, Scholz et al. 2012). Agricultural operations occurring outside the action area can result in discharges that flow into the action area and contribute to cumulative effects of contaminant exposure. It should be noted, the State of California issues Waste Discharge Requirements (WDRs) to dischargers, including irrigators, dairy operations, and cattle operations, that require implementation of Best Management Practices (BMPs) designed to be protective of surface water quality, with benefits for listed fish species. Agricultural operations have monitoring and reporting requirements associated with those WDRs that ensure compliance with BMPs.

### 2.7.3 Wastewater Treatment Plants

Two wastewater treatment plants (one located on the Sacramento River near Freeport and the other on the San Joaquin River near Stockton) have received special attention because of their discharge of ammonia. the Sacramento Regional Wastewater Treatment Plan (SRWTP), in order to comply with Order no. R5-2013-0124, has begun implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board (CVRWQCB) 2013). By May 11, 2021, the SRWTP must meet effluent limits of 2.0 milligrams per liter (mg/L) per day from April to October, and 3.3 mg/L per day from November to March (Central Valley Regional Water Quality Control Board 2016).

However, the treatment plant is currently releasing several tons of ammonia in the Sacramento River each day.

EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. However, few studies have been conducted to assess the effects of ammonia on Chinook salmon, steelhead, or sturgeon. Studies of ammonia effects on various fish species have shown numerous effects, including membrane transport deficiencies, increases in energy consumption, immune system impairments, gill lamellae fusions deformities, liver hydropic degenerations, glomerular nephritis, and nervous and muscular system effects leading to mortality (Eddy 2005, Connon et al. 2011). The ammonia exposure concentrations in these studies may be higher than environmental levels following dilution and downstream movement of SRWTP discharge.

Werner et al. (2008), Werner et al. (2009), and Werner et al. (2010) analyzed the acute effects of SRWTP effluence on delta smelt, rainbow trout, and flathead minnow. Specifically, these studies used 96-h and 7-d lethal (acute exposure) concentrations as endpoints. The studies found that at ammonia/um concentrations reported downstream of the SRWTP discharge, on average below 1 mg/L ammonia/um, lethal toxicity effects are not expected. In general, this lack of toxicity was attributed to the fact that LC50 values were much higher than ammonia concentrations reported in environmental sampling. However, the Werner et al. (2008), Werner et al. (2009), and Werner et al. (2010) studies did not assess sublethal toxicity. Sublethal ammonia toxicity at concentrations similar to what have been reported downstream of SRWTP (less than 1 mg/L) has been demonstrated in fish (Wicks et al. 2002). Therefore, it is not unreasonable to assume that there may be sublethal effects of ammonia effluence on ESA-listed species in the area. In a study of coho salmon and rainbow trout exposed to ammonia, Wicks et al. (2002) showed a decrease in swimming performance due to metabolic challenges and depolarization of white muscle, and found that ammonia is significantly more toxic for active fish. Furthermore, fish exposed to sublethal concentrations of ammonia/um have exhibited increased respiratory activity and heart rate, loss of equilibrium, and hyper excitability (Eddy 2005).

None of these studies assessed the chronic effects of ammonia/um exposure, that may occur at lower concentrations, on the behavior, reproduction, or long-term survival of ESA-listed or surrogate species. However, Werner et al. (2009) concluded that "ammonia/um concentrations detected in the Sacramento River below the SRWTP are of concern with respect to chronic toxicity to delta smelt and other sensitive species."

### 2.7.4 Increased Urbanization

From 2016 to 2060, California's population is projected to grow by 30 percent: from 39.4 million to 51.1 million (0.6 percent annually), which will likely be accompanied by increases in urbanization and housing developments (California Department of Finance 2017). The Delta, East Bay, and Sacramento regions include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo counties, which are expected to increase in population by nearly 3 million people by the year 2060 (California Department of Finance 2017). Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the state as a whole (Delta Protection Commission 2012). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place

additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities.

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions, particularly those which are situated away from waterbodies, will not require Federal permits and thus will not undergo review through ESA Section 7 consultations.

Negative effects on listed fish species and their critical habitats may result from urbanization-induced point and non-point source chemical contaminant discharges within the action area. These contaminants, which include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges, may disrupt various physiological mechanisms and may negatively affect reproductive success and survival rates of listed anadromous fish (Dubrovsky 1998, Scott and Sloman 2004, Whitehead et al. 2004, Scholz et al. 2012).

### 2.7.5 Recreational Activities in the Region

Recreational boating is expected to increase in volume and frequency as urbanization increases. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially will degrade riparian and wetland habitat by eroding channel banks and midchannel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This, in turn, would reduce habitat quality for the invertebrate forage base required for listed fish species. Increased recreational boat operation is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the associated water bodies.

### 2.7.6 Changes in Location, Volume, Timing, and Method of Delivery for Non-CVP/SWP Diversions

Changes in location, volume, timing, and method of delivery for non-CVP/SWP diversions may be fully or partially implemented without requiring ESA Section 7 consultations. While non-CVP/SWP diversions are reasonably certain to occur, the details of implementation are not certain, and changes may be expected to occur due to:

- Implementation of the California Sustainable Groundwater Management Act (SGMA) that requires development and implementation of Groundwater Sustainability Plans;
- Implementation of the California Senate Bill X7-7 provisions which require the state to achieve a 20 percent reduction in urban per capita water use by December 31, 2020;
- Implementation of the California 2009 Delta Reform Act (implementation of portions of the Delta Reform Act also is part of the California Water Action Plan);
- Implementation of the California Water Action Plan released by Governor Jerry Brown in January 2014, specifically, for provisions of the plan that would not necessarily require separate environmental documentation and consultation for related Federal actions.

Reduced reliance on groundwater under SGMA could result in increased surface water diversions in some cases, and associated impacts on listed species. Reduction of urban water use would be expected to have beneficial effects to listed species by reducing diversions.

NMFS does not have information on the specific impacts from these programs to listed fish species or critical habitat at this time; thus, NMFS cannot determine the specific impacts of these programs. NMFS expects that habitat restoration activities under the California Water Action Plan would have short-term effects (sedimentation, turbidity, acoustic noise, temporary habitat disturbance) similar to effects discussed in this opinion for similar habitat restoration activities (see Sections 2.4 Environmental Baseline, 2.5 Effects to Species, and 2.6 Effects to Critical Habitat). In general, NMFS expects that implementation of these programs will improve habitat conditions for listed fish into the future through the increased availability of instream flows and habitat restoration.

### 2.7.7 Activities within the Nearshore Pacific Ocean

Future tribal, state, and local government actions could occur in the form of legislation, administrative rules, policy initiatives, or fishing permits. Activities are primarily those conducted under state and tribal management. These actions may include changes in ocean policy, types of fishing activities, resource extraction, or designation of marine protected areas. The magnitude of impacts associated with these types of activities, on listed fish species or their habitat, is uncertain. Although state, tribal and local governments have developed plans and initiatives to benefit marine fish species, ESA-listed salmonids, green sturgeon, and Southern Residents, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably certain to occur" in its analysis of cumulative effects. Government actions are subject to policy, legislative, and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative.

Private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. These potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in the subsections pertaining to cumulative effects above, whether future non-Federal actions will lead to an increase or decrease in prey available to SRKW, or have other effects on their survival and recovery.

Therefore, the activities in this section are being excluded as they are too speculative to analyze and do not rise to the level of cumulative effects.

### 2.7.8 Other Activities

Other future, non-Federal actions within the action area include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; infrastructure including roads, state and local dredging projects; and state or local levee maintenance that may also destroy or negatively affect habitat and interfere with natural, long term habitat-maintaining processes.

Power plant cooling system operations can also affect aquatic habitat. A Statewide Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling, also called the Once-Through

Cooling (OTC) Policy, adopted by the SWRCB in 2010 under Resolution No. 2010–0020, and amended in 2017 under Resolution No. 2017-0047, requires existing cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts (State Water Resources Control Board 2010b, 2017a). Since this policy was adopted, several power-generating units have been retired or repowered (Statewide Advisory Committee 2019). For example, Contra Costa Power Plant, which was owned and operated by NRG Delta, LLC, was retired in 2013 and replaced with the new natural gas power plant, Marsh Landing Generating Station. Additionally, the Pittsburg Generating Station (PGS) ceased operations in December of 2016 (Statewide Advisory Committee 2019).

The once-through cooling system intake process can cause the impingement and entrainment of estuarine and marine animals, kill organisms from all levels of the food chain, and disrupt the normal processes of the ecosystem. Additionally, the plant can discharge heated water that can reach temperatures as high as 100°F into the action area. This sudden influx of hot water can negatively affect the ecosystem and the animals living in it (San Francisco Baykeeper 2010). The OTC Policy includes provisions that mitigate impingement and entrainment impacts resulting from cooling water intakes, decreasing the occurrence of these events for ESA-listed fish at all life stages (Statewide Advisory Committee 2019). However, it does not address problems associated with elevated temperatures in discharged water.

### 2.8 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species.

For each response to an action, we assign a relative magnitude of effect (high, medium, or low). This is a qualitative assessment of the likelihood of a fitness consequence occurring that allows for incorporation of some aspects of uncertainty (for instance, an infrequent but documented presence of a small number of individuals at a particular time). It is based on an assessment of the severity of the stressor, the proportion of the population exposed, and the frequency of exposure. Severity is categorized as lethal, sublethal, or minor. The proportion of the population exposed (for the fish species) is characterized similarly as in (National Marine Fisheries Service 2009b) as large (70 percent or more exposed), medium (more than 2 percent, but less than 70 percent exposed), and small (exposure not expected to exceed 2 percent). We note that this includes intra-annual exposure (i.e., exposure of the same cohort to a stressor multiple times in a year). The frequency of exposure is categorized as high (very frequent; occurring in 75 percent or more years), medium (moderately frequent; occurring in 25-75 percent of years), and low (infrequent; occurring in fewer than 25 percent of years). Table 2.1.3-2 shows combinations of severity, proportion, and frequency that result in the various magnitudes of effect.

The weight of evidence for stressor effect identified in Table 2.1.3-1 is based on the best available scientific information and is categorized based on the characteristics of the analytical method, with modifications to include statistical power of analytical methods. Weights are defined as follows:

- High: Supported by multiple scientific and technical publications, especially if conducted on the species within the area of effect, quantitative data, and/or modeled results; high power in interpretation of analytical results;
- Medium: Evidence between high and low definitions; and
- Low: One study, or unpublished data, or scientific hypotheses that have been articulated but not tested; low power in interpretation of analytical results.

This section is organized by species to integrate and synthesize first the effects to the species survival and recovery and second the effects to that species' critical habitat. The information for the survival and recovery analysis is organized further and presented in the following stepwise order: (1) Status of the Species and Environmental Baseline; (2) Summary of Proposed Action Effects to Individuals; (3) Assess Risk to the Population; and (4) Assess Risk to the ESU/DPS. This same general order of summarizing status and effect is used to present the critical habitat analysis using the steps: (1) Status of Critical Habitat and Environmental Baseline; (2) Summary of Proposed Action Effects on Physical or Biological Features of Critical Habitat; and (3) Impact to the Critical Habitat at the designation level.

### 2.8.1 Sacramento River Winter-run Chinook Salmon

### 2.8.1.1 Status of the Species and Environmental Baseline

This section is a brief summary of the status of the winter-run Chinook salmon ESU and the environmental conditions that lead to that status. A more complete description of winter-run Chinook salmon's status is presented in Section 2.2 Status of the Species and Critical Habitat and Appendix B, and the environmental baseline is fully characterized in Section 2.4 Environmental Baseline.

Winter-run Chinook salmon are particularly important among California's salmon runs because they exhibit a life-history strategy found nowhere else in the world. These Chinook salmon are unique because they spawn during the summer months when air temperatures usually approach their warmest. As a result, winter-run Chinook salmon require stream reaches with cold-water sources to protect their incubating eggs from the warm ambient conditions.

Because of this need for cold water during the summer, winter-run Chinook salmon historically spawned only in rivers and creeks fed by cold water springs, such as the Little Sacramento, McCloud, and Pit rivers, and Battle Creek (Lindley et al. 2004). The construction of Shasta and Keswick dams eliminated access to the Little Sacramento, McCloud, and Pit rivers, extirpating the winter-run Chinook salmon populations that spawned and reared there. The fish from these three different populations above Shasta Dam were forced to mix and spawn as one population downstream of Keswick Dam on the Sacramento River. After this loss of historic spawning habitat, winter-run Chinook salmon abundance declined, but still reached as high as 118,000 spawners in 1969 – two orders of magnitude more than the current population (Figure B-2 in Appendix B). Construction and operation of hydropower facilities affected Battle Creek as well,

blocking and degrading habitat so the watershed could no longer support a winter-run Chinook salmon population.

Currently, only the one small population of winter-run Chinook salmon spawning downstream of Keswick Dam exists, making this species particularly vulnerable to environmental pressures such as the 2012-2015 drought. This vulnerability manifested with the drought as three consecutive year classes suffered heavy losses due to an inability to release cold water from Shasta Reservoir throughout the egg and fry life stages. Warm water releases from Shasta Reservoir contributed to egg-to-fry mortality rates of 85 percent in 2013, 94 percent in 2014, and 96 percent in 2015, the highest levels since estimates of that statistic began in 1996. Mortality decreased after the drought ended with 76 percent mortality in 2016 and 56 percent mortality in 2017.

The Sacramento River winter-run Chinook salmon ESU is at high extinction risk because there is only one naturally-spawning population, and it is not within its historical range (Lindley et al. 2007, National Marine Fisheries Service 2016c). Of over 165 species that NMFS protects under the Endangered Species Act, the winter-run Chinook salmon ESU is considered one of just nine²⁹ species that are most at risk of extinction in the near future, per the Species in the Spotlight initiative (National Marine Fisheries Service 2015e).

The extinction risk of the winter-run Chinook salmon population has increased since the 2007 assessment (Table 2.4.3 2). Based on the Lindley et al. (2007) criteria, the population is at high extinction risk in 2019. High extinction risk for the population was triggered by the hatchery influence criterion, with a mean of 66 percent hatchery origin spawners over the last generation from 2016 through 2018. The threshold for high risk associated with hatchery influence is 50 percent hatchery origin spawners.

Reclamation established a "without-action" scenario as part of the BA's Environmental Baseline to isolate and define potential effects of the proposed action apart from effects of non-proposed action. NMFS considers the without-action scenario to represent effects related to the existence of CVP and SWP facilities. The without-action scenario provides context for how these facilities have shaped the habitat conditions for species and critical habitat in the action area. Under Reclamation's "without action" scenario, there would be both positive and negative effects on the status of winter-run Chinook salmon. Higher flows in winter and spring could have both positive and negative effects on salmonids. Benefits of higher flows include lower water temperatures, increased dissolved oxygen, increased habitat complexity, more rearing habitat, more refuge habitat, increased availability of prey, less predation risk, less entrainment risk, lower potential for pathogens and disease, lower concentrations of toxic contaminants, and emigration cues. Reduced flows during dry fall months would have negative impacts on spawning adults, eggs, and alevin, and on rearing juvenile salmonids, resulting in increased temperature-dependent mortality of eggs, reduced juvenile growth rate and higher mortality of the juveniles, and a reduced population abundance.

However, as discussed previously, the Environmental Baseline also includes the effects of past and current operations of the CVP and SWP, and the additional effects of habitat restoration, predation from invasives, water quality, and other effects on species from Federal, State, and private actions to inform the current condition of winter-run Chinook salmon. As discussed

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²⁹ The NMFS Species in the Spotlight initiative was initially launched highlighting eight species most in need of urgent protection; a ninth species was added in 2019.

above, the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years.

### 2.8.1.2 Summary of Proposed Action Effects

Proposed action-related effects to winter-run Chinook salmon are summarized in Table 2.8.1-1. Detailed descriptions regarding the exposure, response, and risk of winter-run Chinook salmon to these stressors are presented in Section 2.5 Effects of the Action to the Species.

As shown in Table 2.8.1-1, proposed action-related stressors are expected to reduce the fitness of individuals during the adult, egg, fry, and juvenile life stages. Thus, each freshwater life stage will be harmed to some degree by the PA, with extensive lethal impacts expected to eggs, fry, and juveniles. The combined effect of these stressors throughout the life cycle likely has important consequences for the viability of the population, as Naiman and Turner (2000) demonstrated that it is possible to drive a Pacific salmon population to extinction (or to increase population size), by only slight changes in survivorship at each life history stage (see Figure 2.1.3-5).

Table 2.8.1-1 Summary of proposed action-related effects on winter-run Chinook salmon organized by division component. Within each division, components are listed top to bottom in the following order: high magnitude stressors, high magnitude benefits, medium magnitude stressors, medium magnitude benefits, low magnitude stressors, low magnitude benefits, uncertain stressors/benefits.

Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division	Division
W. 1997		toda .
Tier 2 (Shasta Cold Water Pool Mgmt.)	Tier I (Shasta Cold Water Pool Mgmt.)	Action Compone nt
Water Temperature under Tier 2 management	Water Temperature under Tier 1 management	Stressor/Facto r
Eggs/Fry (Keswick Dam - CCR gauge)	Eggs/Fry (Keswick Dam - CCR gauge)	Life Stage (Location)
May - October (May 15 - October)	May - October (May 15 - October)	Life Stage Timing (Work Window Intersection)
Temperatures higher than 53.5°F would result in reduced survival (increase in mean temperature dependent mortality of 12 percent [Anderson] and 15 percent [Martin]; the standard deviations are +/- 13 percent	Temperatures higher than 53.5°F would result in reduced survival (mean temperature dependent mortality of 5 percent [Anderson] and 6 percent [Martin]; the standard deviations are +/- 8 percent [Anderson] and +/- 9 percent [Martin])	Individual Response and Rationale of Effect
Lethal	Lethal	Severity of Stressor/ Level of Benefit
Large (33.1% of days >53.5°F for 100% of the populati on)	Large (23.3% of days >53.5°F for 100% of the populati on of eggs/fry	Proport ion of Populat ion Expose d
Low to Medium (17 - 35% of years)	Medium (45 - 68% of years)	Frequen cy of Exposur e
High	High	Magni tude of Effect
High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	Weight of Evidence
Reduced survival probabilit y (12% - 15% temperature dependent mortality with standard deviations of +/- 13 percent [Anderson] and +/-	Reduced survival probabilit y (5% - 6% temperatu re dependent mortality with standard deviations of +/- 8 percent [Anderso n] and +/- 9 percent [Martin]).	Probable Change in Fitness

Opper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division	Division
(Shasta (Shasta Cold Water Pool Mgmt.)	Tier 3 (Shasta Cold Water Pool Mgmt.)	Action Compone nt
Temperature under Tier 4 management	Water Temperature under Tier 3 management	Stressor/Facto
(Keswick Dam - CCR gauge)	Eggs/Fry (Keswick Dam - CCR gauge)	Life Stage (Location)
October (May 15 - October)	May - October (May 15 - October)	Life Stage Timing (Work Window Intersection)
higher than 53.5°F would result in reduced survival probability (increase in mean temperature dependent mortality of 79 percent [Anderson] and 81 percent [Martin]; the standard denistics	Temperatures higher than 53.5°F would result in reduced survival (increase in mean temperature dependent mortality of 28 percent [Anderson] and 34 percent [Martin]; the standard deviations are +/- 25 percent [Anderson] and +/- 31 percent [Martin])	Individual Response and Rationale of Effect  [Anderson] and +/- 16 percent [Martin])
Leman	Lethal	Severity of Stressor/ Level of Benefit
Large (86% of days >53.5°F for 100% of the populati on)	Large (65% of days >53.5°F for 100% of the populati on)	Proport ion of Populat ion Expose d
- 7% of years)	Low (7% - 15% of years)	Frequen cy of Exposur e
	High	Magni tude of Effect
Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	Weight of Evidence
survival probability (79% - 81% mean temperature dependent mortality with standard deviations of +/- 14 percent	Reduced survival probabilit y (28% - 34% temperatu re dependent mortality with standard deviations of +/- 25 percent [Anderson] and +/- 31 percent [Martin]).	Probable Change in Fitness 16 percent [Martin]).

Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division		Division
Spring Pulse Flow	Fall and Winter Refill and Redd Maintena nce		Action Compone nt
Reduced storage caused by spring pulse releases (May 1 – May 15), reduces Reclamation's ability to provide suitable spawning and incubation	To build storage for the subsequent year class, fall flows are reduced from the high summer flow. This reduction of flows is likely to influence Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function.		Stressor/Facto r
Eggs/Fry (Upper Sacramento River)	Juveniles (Upper Sacramento River)		Life Stage (Location)
May – October (NA)	July - December (October, November)		Life Stage Timing (Work Window Intersection)
Summer temperatures higher than 53.5°F would result in increased egg/fry mortality.	Decreased month-to-month flows resulting in stranding and decreased floodplain inundation and side-channel habitat.	14 percent [Anderson] and +/- 16 percent [Martin]).	Individual Response and Rationale of Effect
Lethal	Lethal		Severity of Stressor/ Level of Benefit
Small – Medium (<2 – 6%)	Medium (<50% of the populati on)		Proport ion of Populat ion Expose
Medium (<75% of years)	Low (20% of years)		Frequen cy of Exposur e
Mediu m - High	High		Magni tude of Effect
Medium: High level of understandi ng of the relationship between temperatur e and egg/fry survival, but limited	Medium: Supported by technical publication s specific to the region and species. Quantitative results include WUA analysis and month-to-month floodplain inundation.		Weight of Evidence
Decreased survival probabilit y (<2% - 6% egg/fry mortality)	Reduced survival probabilit y	n] and +/- 16 percent [Martin]).	Probable Change in Fitness

Ezsc	ד מ ע		
Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division		Division
Winter Minimum flows	Shasta Cold Water Pool Mgmt.		Action Compone nt
Flow Conditions	Water Temperatures. Redds constructed earlier than May 15 would not be protected. Eggs/Fry still in redds after the end date of temperature management (10/31, or when 95% alevin have emerged) would also not protected.	Water Temperatures	Stressor/Facto r
Juveniles (Upper mid- Sacramento River)	Eggs/Fry (Keswick Dam - CCR gauge)		Life Stage (Location)
July - December (December)	May - October (May 1 - May 15, and 95% WR alevin emergence - October 31)		Life Stage Timing (Work Window Intersection)
Decreased month-to-month flows resulting in stranding caused by a loss of floodplain inundation and	Temperatures higher than 53.5°F would result in reduced survival		Individual Response and Rationale of Effect
Lethal	Lethal		Severity of Stressor/ Level of Benefit
Medium (5-10% of populati on)	Small to Medium		Proport ion of Populat ion Expose d
Low (20% of years)	High		Frequen cy of Exposur e
High	Mediu m - High		Magni tude of Effect
Medium: Supported by select technical publication s specific to the region and	High: Survival- temperatur e relationship supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	understandi ng of the effects of seasonal operations on storage and temperatur e.	Weight of Evidence
Decreased survival probabilit y	Reduced survival		Probable Change in Fitness

Division		Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division
Action Compone nt		Delta Smelt Sunnmer- Fall Habitat	LSNFH Productio n (tier 4 interventi on)
Stressor/Facto r		Water Temperature	Increased production at LSNFH. Hatchery effects (minimization for Water Temperatures)
Life Stage (Location)		Eggs/Fry (Keswick Dam - CCR gauge)	Adults (Upper Sacramento River)
Life Stage Timing (Work Window Intersection)		May - October (May 15 - October)	December - August (May - August)
Individual Response and Rationale of Effect	side-channel habitat.	Framework programmatic action component. Temperatures higher than 53.5°F would result in reduced survival	Intervention measure to address a lack of suitable spawning and rearing habitat during periods of drought. Adult fish are brought into LSNFH to augment natural production. Covered under
Severity of Stressor/ Level of Benefit		Lethal	Beneficial : High
Proport ion of Populat ion Expose d		Medium - High	High (Uncert ain)
Frequen cy of Exposur e		Low	Low (7% of years)
Magni tude of Effect		High	High
Weight of Evidence	species. Quantitativ e results include month-to- month change.	High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	High: Multiple scientific and technical publication s covering the influence of hatchery production on wild populations
Probable Change in Fitness		Decreased survival probabilit y	Short- term increased reproducti ve success at the framewor k-level, but also reduced viability due to increased

Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division	Division
Temperat ure Modeling Platform	Small Screen Program (Spawnin g/rearing habitat restoratio n)	Action Compone nt
Water Temperature under Tier management	Entrainment/I mpingement at water diversions	r r
Eggs/Fry (Keswick Dam - CCR gauge)	Juveniles (Middle Sacramento River)	(Location)
May - October (May 15 - October)	July - December	Timing Timing (Work Window Intersection)
Improved modeling should help minimize temperature dependent mortality	Framework level action component. Operation of installed fish screens are assumed to comply with NMFS and CDFW fish screening guidance. Reduced entrainment into unscreened diversions and minimized potential for injury caused by impingement.	Response and Rationale of Effect  the USFWS 2016 HGMP
Beneficial : High	Beneficial : High	of of Stressor/ Level of Benefit
Large	Medium (Juvenil es <50% passage at RBDD)	Proport ion of Populat ion Expose d
Medium	High (Operatio ns)	e e
High	High	Magni tude of Effect
High: Supported by multiple scientific and technical publication s that include quantitative	Low: (Programm atic action component) very little information available as to how this action component would be implemente d or its effects when operated.	Evidence
Increased survival probabilit y	Increased survival probabilit y	Change in Fitness hatchery influence

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Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division		Division
Drought and Dry Year Actions	Actions for Year After Two Low Survival Years		Action Compone nt
Water Temperature	Water Temperature		Stressor/Facto
Eggs/Fry (Keswick Dam - CCR gauge)	Eggs/Fry (Keswick Dam - CCR gauge)		Life Stage (Location)
May - October (May 15 - October)	May - October (May 15 - October)		Life Stage Timing (Work Window Intersection)
Temperatures higher than 53.5°F would result in reduced survival	Temperatures higher than 53.5°F would result in reduced survival		Individual Response and Rationale of Effect
Beneficial : High	Beneficial : High		Severity of Stressor/ Level of Benefit
Large	Large	3	Proport ion of Populat ion Expose d
Low	Low		Frequen cy of Exposur e
High	High		Magni tude of Effect
High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	models specific to the region and species.	Weight of Evidence
Increased survival probabilit y	Increased survival probabilit y		Probable Change in Fitness

<b>Division</b> Unner	Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division
Action Compone nt	Drafting of Temperat ure Managem ent Plan Using Conservat ive Forecasts	Wilkins Slough intakes (Cold water pool mgmt.)
Stressor/Facto r	Water Temperature	Entrainment/I mpingement at water diversions, Flow Conditions
Life Stage (Location)	Eggs/Fry (Keswick Dam - CCR gauge)	Adults, Juveniles (Middle Sacramento River)
Life Stage Timing (Work Window Intersection)	May - October (May 15 - October)	December - July (May - July), July - December (July - October)
Individual Response and Rationale of Effect	Temperatures higher than 53.5°F would result in reduced survival	Framework level action component. Operation is assumed to comply with NMFS and CDFW fish screening guidance reducing the potential for entrainment/impingement at diversions.
Severity of Stressor/ Level of Benefit	Beneficial : High	Beneficial : High
Proport ion of Populat ion Expose d	Large	Low (Adults) , Medium (Juvenil es <50% passage at RBDD)
Frequen cy of Exposur e	High	High (Yearly Operatio ns)
Magni tude of Effect	High	Mediu m - High
Weight of Evidence	High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	Low: (uncertain) very little information available as to how this action component would be implemente d or its effects when operated.
Probable Change in Fitness	Increased survival probabilit y	Increased survival probabilit y

1	Upper Winter Flow Juveniles Sacramen Minimum Conditions, (Upper mid- to/Shasta flows Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function	Upper Winter Sacramen Minimum Temperature (Keswick Octobe to/Shasta Division Gauge)  Water Eggs/Fry May - CCR (Keswick Octobe gauge)
nt -	num T	r mm
	rian rat and eam of Natural r phology	er perature
8	Juveniles (Upper mid- Sacramento River)	Eggs/Fry (Keswick Dam - CCR gauge)
(Work Window Intersection)	July - December (December)	May - October (May 15 - October)
Rationale of Effect	Reduced growth and potentially increased competition and predation related to decreased habitat carrying capacity (WUA) at lower flows	Temperatures higher than 53.5°F would result in reduced survival (increase in mean temperature dependent mortality of 28 percent [Anderson] and 34 percent [Martin]; widest range of 25 and 75 percentiles for 2 different models is 7 to 59
Stressor/ Level of Benefit	Sublethal	Beneficial : High
Populat ion Expose d	Medium (5-10% of populati on)	Medium (5-10% of populati on)
Exposur e	Low (20% of years)	Low (20% of years)
Effect	Mediu m	Mediu m
	Low: Substantial uncertainty with WUA analyses for the juvenile rearing life stage. Quantitativ e results include WUA analysis.	High: Supported by select technical publication s specific to the region and species. Quantitativ e results include month-to- month change.
in Fitness	Decreased growth rate	Increased survival probabilit y

Division	Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division
Action Compone nt	Fall and Winter Refill and Redd Maintena nce	Spring Pulse Flow
Stressor/Facto r	Water Temperature	Flow Conditions, Loss of Natural River Morphology and Function Passage Impediments/B arriers
Life Stage (Location)	Eggs/Fry (Keswick Dam - CCR gauge)	Migrating Adults (Middle, Lower Sacramento River)
Life Stage Timing (Work Window Intersection)	May - October (May 15 - October)	December - July (March - May 15)
Individual Response and Rationale of Effect	Temperatures higher than 53.5°F would result in reduced survival (increase in mean temperature dependent mortality of 28 percent [Anderson] and 34 percent [Martin]; widest range of 25 and 75 percentiles for 2 different models is 7 to 59 percent)	Elevated flows may facilitate swimming past barriers, or they may merely serve as a cue for migration. High flows are also correlated with lower temperatures that benefit females migrating upriver by ensuring that eggs are not damaged before
Severity of Stressor/ Level of Benefit	Beneficial : High	Beneficial : Low
Proport ion of Populat ion Expose d	Medium (<50% of the populati on)	Large
Frequen cy of Exposur e	Low (20% of years)	Medium (<75% of years)
Magni tude of Effect	Mediu m	Mediu m
Weight of Evidence	High: Supported by select technical publication s specific to the region and species.	Medium: Correlation of flow and migration supported by multiple scientific and technical publication s but magnitude of benefit uncertain.
Probable Change in Fitness	Increased survival probabilit y	Improved reproducti ve success

		3
Division	Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division
Action Compone nt	Fall and Winter Refill and Redd Maintena nce	Spring Mgmt. of Spawning Locations
Stressor/Facto	To build storage for the subsequent year class, fall flows are reduced from the high summer flow. This reduction of flows is likely to influence Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function.	Water Temperature, Spawning Habitat Availability
Life Stage (Location)	Juveniles (Upper Sacramento River)	Adults (Upper Sacramento River)
Life Stage Timing (Work Window Intersection)	July - December (October, November)	December - July (April - May)
Individual Response and Rationale of Effect	Decreased habitat carrying capacity (WUA) at lower flows providing decreased feeding conditions, and potentially increased competition and predation.	Framework programmatic action component. Proposed research and management to determine the effect of water temperatures on the timing and location of spawning. Warmer temperatures may delay spawning.
Severity of Stressor/ Level of Benefit	Sublethal	Low (Uncertain )
Proport ion of Populat ion Expose d	Medium (<50% of the populati on)	Large
Frequen cy of Exposur e	Low (20% of years)	High (Uncertai n)
Magni tude of Effect	Mediu m	Mediu m (Uncert ain)
Weight of Evidence	Low: Substantial uncertainty with WUA analyses for the juvenile rearing life stage. Quantitativ e results include WUA analysis.	Low: A number of scientific and technical publication s have suggested a relationship between temperatur e and spawning timing but a direct effect is still
Probable Change in Fitness	Decreased growth rate, Reduced survival probabilit y	Improved reproducti ve success

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osur Effect  unknown and in need of further understandi ng.  Low (Uncert (uncertain) little information available as to how this action component would be implemente d or its effects.			action	July), July -	(Middle	arriers, Flow	intakes	to/Shasta
unknown and in need of further understandi ng. Low Low: (Uncert (uncertain) information available as to how this action component would be implemente d or its effects.	(Adults) (Co		programmatic	July (June -	Juveniles	Impediments/B	Slough	Sacramen
unknown and in need of further understandi ng.  Low Low: (Uncert (uncertain) little information available as to how this action component would be implemente d or its effects.	Medium Unc	Lethal	Framework	December -	Adults,	Passage	Wilkins	Upper
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sur Effect  unknown and in need of further understandi ng. Low Low: (Uncert (uncertain)	of the year	J	provide more	(October,	Sacramento	Loss of	sition	to/Shasta
sur Effect  unknown and in need of further understandi ng. Low Low:	_	(Uncertain	coordination may	December	(Upper	Conditions,	Decompo	Sacramen
Effect  unknown and in need of further understandi ng.	<u>в</u>	Low	Proposed	July -	Juveniles	Flow	Rice	Upper
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tude of Evidence	-	of ,	Response and	Timing	(Location)	-	Compone	
Frequen Magni Weight of Probable	Proport Fre	Severity	Individual	Life Stage	Life Stage	Stressor/Facto	Action	Division

			- 1
Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division		Division
Spawning Gravel Injection (Spawnin g/rearing habitat restoratio n)	Juvenile Trap and Haul (tier 4 interventi on)		Action Compone nt
Spawning Habitat Availability, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Monitoring, Maintenance, Research Studies, etc. (minimization for Water Temperatures)	in-water construction and installation of fish screens.	Stressor/Facto r
Adults(Uppe r Sacramento River)	Juveniles (Upper Sacramento River)		Life Stage (Location)
December - July (Uncertain, typical in- water work windows don't apply)	July - December (uncertain)		Life Stage Timing (Work Window Intersection)
Increased habitat quality and quantity. Framework programmatic action component, no description of timing, or extent of effects.	Uncertain. Framework programmatic action component. Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of Juvenile winter-run during Tier 4 water temperature operations.	appropriate in- water work window and include BMPs and minimization measures to limit potential effects to species.	Individual Response and Rationale of Effect
Beneficial : Low	Mitigation (Lethal)		Severity of Stressor/ Level of Benefit
Uncertai n, but at least low	Uncertai n.		Proport ion of Populat ion Expose d
High	Low (7% of years)		Frequen cy of Exposur e
Uncert ain, but at least low	Uncert ain, High		Magni tude of Effect
Low: (Programm atic action component) very little information available as to how or where this action component would be	Low: (Programm atic action component) very little information available as to how this action component would be implemente d or as to its effects.	(constructi on).	Weight of Evidence
Increased reproducti ve success continuin g from the baseline	Increased survival probabilit y		Probable Change in Fitness

Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division	Division
Small Screen Program (Spawnin g/rearing habitat restoratio n)	Side-Channel habitat (Spawnin g/rearing habitat restoratio n)	Action Compone nt
Passage Impediments/B arriers, Flow Conditions, Loss of Riparian Habitat and Instream Cover, Stressors associated with in-water construction and installation of fish screens.	Riparian vegetation, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Stressor/Facto
Adults, Juveniles (Middle Sacramento River)	Juveniles (Middle Sacramento River)	Life Stage (Location)
December - July (June - July), July - December (July - October)	July - December (July - October)	Life Stage Timing (Work Window Intersection)
Framework programmatic action component. Construction activities are not described. Assumed construction effects related to installation of fish screens include: changes in flow, stranding (installation of coffer dams), and handling.	Increased habitat quality and quantity. Framework programmatic action component.	Individual Response and Rationale of Effect
Lethal	Uncertain Beneficial : Low	Severity of Stressor/ Level of Benefit
Medium (Adults) , Medium (Juvenil es <50% passage at RBDD)	Uncertai n, but at least low	Proport ion of Populat ion Expose d
Uncertain (Construction)	High (Permane nt)	Frequen cy of Exposur e
Uncert ain	Uncert ain, but at least low	Magni tude of Effect
Low: (Programm atic action component) very little information available as to how this action component would be implemente d.	Low: (Programm atic action component ) very little information available as to how or where this action component would be implemente d or the extent of its effects.	Weight of Evidence  Evidence implemente d or the extent of its effects.
Reduced survival probabilit y	Increased growth continuin g from the baseline	Probable Change in Fitness

Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division	Division
, B	, ,	
Shasta TCD improvem ents (Cold water pool mgmt.)	Adult rescue (interventi on)	Action Compone nt
Water Temperature	Passage Impediments/B arriers, Entrainment/I mpingement at water diversions	Stressor/Facto r
NA	Adults (Middle Sacramento River)	Life Stage (Location)
NA	December - July	Life Stage Timing (Work Window Intersection)
Framework programmatic action component. Dependent on configuration of a Shasta Dam raise. Unknown changes/modifica tions to existing TCD. Unknown effect.	Framework programmatic action component. Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of adult salmonids entrained in water diversions (e.g. Yolo and Sutter Bypasses).	Individual Response and Rationale of Effect
NA	Mitigation (Lethal)	Severity of Stressor/ Level of Benefit
NA	Uncertai n	Proport ion of Populat ion Expose d
NA	Uncertain	Frequen cy of Exposur e
NA	Uncert	Magni tude of Effect
Low: (uncertain) very little information available as to how this action component would be implemente d or its effects.	Low: (Programm atic action component) very little information available as to how this action component would be implemente d or as to its effects.	Weight of Evidence
Dependen ton configurat ion of a Shasta Dam raise.	Increased reproducti ve success, Increased survival probabilit y	Probable Change in Fitness

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Division	Upper Sacramen to/Shasta Division	Upper Sacramen to/Shasta Division
Action Compone nt	2.5.2.4 Operation of a Shasta Dam Raise	Battle Creek Restoratio n (Cold water pool mgmt.)
Stressor/Facto	NA	NA
Life Stage (Location)	NA	NA
Life Stage Timing (Work Window Intersection)	NA	NA
Individual Response and Rationale of Effect	None. Reclamation has committed to no change in operations with the inclusion of a Shasta Dam raise such that there will be no change in the frequency of meeting management criteria nor will there be any change in the timing and volume of releases.	Reclamation commits to accelerate existing efforts. Covered under 2005 NMFS/USFWS Biological Opinions
Severity of Stressor/ Level of Benefit	NA	NA
Proport ion of Populat ion Expose d	NA	NA
Frequen cy of Exposur e	NA	NA
Magni tude of Effect	NA	NA
Weight of Evidence	NA	NA
Probable Change in Fitness	None	Existing Battle Creek actions included in baseline. New accelerate d componen ts are uncertain but could be beneficial if specific.

Delta	Division
DCC Gate operations	Action Compone nt
Altered Hydrodynamic s downstream of DCC location	Stressor/Facto
Juveniles - Sacramento River -Delta	Life Stage (Location)
Juvenile migration and rearing - Oct - April	Life Stage Timing (Work Window Intersection)
Increased mortality when gates are open due to changes in routing or transit time through interactions with changes in river flow and tidal influence downstream of DCC location and gate operations	Individual Response and Rationale of Effect
Minor to Lethal	Severity of Stressor/ Level of Benefit
High- opening of gates reduces the proporti on of riverine reaches adjacent to the DCC location closing of gates extends the riverine reaches farther downstr eam. Entire season of emigrati on occurs with gates in either open or closed position.	Proport ion of Populat ion Expose d
High	Frequen cy of Exposur e
Low- High	Magni tude of Effect
High - There are a number of publication s regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modelling results.	Weight of Evidence
Reduced fitness and/or survival when gates are open; lesser effect in final PA due to revised DCC operations in December -January	Probable Change in Fitness

<b>Division</b> Delta	Delta	Delta
Action Compone nt	CVP Improvem ents	CVP/SW P exports
Stressor/Facto r CO2 injections	CO2 injections	Shift in Operations
Life Stage (Location)  Juveniles -	Juveniles - Sacramento River –Delta	Juveniles - Sacramento River –Delta
Life Stage Timing (Work Window Intersection)	Juvenile migration and rearing - Oct - April	Juvenile migration and rearing - Oct - April
Individual Response and Rationale of Effect  Removal of	Removal of predators from secondary channel at the Tracy Fish Collection Facility	Shift in exports to CVP from SWP to reduce impacts of predation from the CCF when capacity at CVP exists
Severity of Stressor/ Level of Benefitial	Beneficial : High	Beneficial : High
Proport ion of Populat ion Expose d Medium	Medium	Small
Frequen cy of Exposur e	High	Medium
Magni tude of Effect	High	Mediu m
Weight of Evidence  Medium –	Medium – several studies have looked at predation impacts in the salvage process, long term effectivene ss of this method is not certain	Medium - Several studies show lower losses at the CVP for salvaged fish - availability of capacity at the CVP is uncertain
Probable Change in Fitness	Increased survival	Increased survival

										Delta							_																							Delta						
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								'	operations	DCC Gate																												'	operations	DCC Gate				nt	Compone	-
										Transit times																														Routing					7	
								River –Delta	Sacramento	Juveniles -																											Delta	River –	Sacramento	Juveniles -				10000	(Location)	
							April	rearing - Oct -	migration and	Juvenile																											April	rearing - Oct -	migration and	Juvenile		Intersection)	Window	(Work	2	Imino
		predators	predators	exposure to	increased	with concurrent	migration times	increased	mortality due to	Increased																									rates	lower survival	delta interior with	routing into the	mortality due to	increased		The control of the co	Effect	Rationale of	nun senodessi	Moenoneo ono
										Lethal																														Lethal		Benefit	Level of	Stressor/		2
Dec 1	y crosed	v closed	typicall	Nov 30	through	Oct 1	from	open	- gates	Medium	January	10	of circ	the end	es by	emigrat	on	populati	. ××	Juvenile	10	ed 30 %	ed 50 %	Estimat	May 20	through	Feb 1	Closed	Jan 31.	through	Dec 1	y closed	typicall	Nov 30,	through	Oct 1	from	open	- gates	Medium	p.	Expose	ion	Populat	1011 01	ION OF
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Delta and	Norm	North	Various	survival in	the relative	s regarding	publication	number of	I here are a	High -											results.	moderning	modelling	by	sunnorted	conclusions	routes:	migratory	Delta	Central	Delta and	North	various	survival in	the relative	s regarding	publication	number of	I nere are a	High -					TATOCHEC	- Vicence
In	operations	onerations	חרר	revised	due to	final PA	effect in	lesser	survival;	Reduced																			-January	December	B.	operations	DCC	revised	due to	final PA	effect in	lesser	survivai;	Reduced				in Fitness	Change	nonge

2.00	1	
Delta		Division
CVP/SW P South Delta Exports		Action Compone nt
Altered hydrodynamics in south Delta/ routing		Stressor/Facto
Juveniles - Sacramento River -Delta		Life Stage (Location)
Juvenile migration and rearing - Oct - April		Life Stage Timing (Work Window Intersection)
Mortality or decrease in condition due to migratory delays in response to altered hydrodynamics in channels of the south Delta. Loss of appropriate migratory cues. Delays increase transit time and exposure to predators, poor water quality, and contaminants.  No protections / reduced protections prior		Individual Response and Rationale of Effect
Sublethal to Lethal		Severity of Stressor/ Level of Benefit
Medium	through Jan 31. Closed Feb 1 through May 20. Estimat ed 50% of juvenile WR populati on emigrat es by the end of January	Proport ion of Populat ion Expose d
High-continual exports		Frequen cy of Exposur e
Mediu m- High		Magni tude of Effect
Medium to High - effects of hydrodyna mics well studied and modelled. Effects of hydrodyna mics on salmonid migrations in south Delta less certain.	Central Delta migratory routes; conclusions supported by modelling results.	Weight of Evidence
Reduced survival, reduced growth; likely lesser effect in final PA due to revised loss thresholds	December -January	Probable Change in Fitness

Division		Delta	Delta
Action Compone nt		CVP/SW P South Delta Exports	DCC Gate operations
Stressor/Facto		Entrainment and loss at the south Delta export facilities	Routing
Life Stage (Location)		Juveniles - Sacramento River –Delta	Adults - Sacramento River - Delta
Life Stage Timing (Work Window Intersection)		Juvenile migration and rearing - Oct - April	Nov - June
Individual Response and Rationale of Effect	to January 1 OMR management onset for 5% of WR population in Delta.	Loss is approximately 35% at the CVP and 84% at the SWP fish salvage facilities. No protections / reduced protections prior to January 1 OMR management onset for 5% of WR population in Delta	Increased straying into the Mokelumne River system when gates are opened for water quality concerns, followed by migratory delays when gates are closed
Severity of Stressor/ Level of Benefit		Sublethal to Lethal	Minor
Proport ion of Populat ion Expose d		Small	Low-gates opened infreque ntly in January, closed Februar y 1 - May 20
Frequen cy of Exposur e		High	Medium
Magni tude of Effect		Mediu m - High. sustain ed high frequen cy exposu re on small proport ion of populat	Low
Weight of Evidence		High - Numerous studies have evaluated the efficiency of the screening facilities, predation, as well as survival through the facilities	Medium - tagging studies related to straying of Chinook through the DCC when open.
Probable Change in Fitness		Reduced survival lesser effect in final PA due to revised loss thresholds	Delayed migration, possible reduction of spawning success; lesser effect in final PA due to revised DCC operations in December January

Minor	Small		Small High
inoi		Small	Small High
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to Lethal	-	Medium	Medium
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01	Danulas	e0 //.	Exposur
of its	ion of	+	ev of
		Proport ion of Populat f ion Expose d Small to Medium	Proport Frequen ion of cy of Populat Exposur f ion e Expose d Small to Medium

Delta	Delta	Delta	Division
			ion
North Bay Aqueduct	North Bay Aqueduct	North Bay Aqueduct	Action Compone nt
Impingement/ capture during aquatic weed cleaning	Entrainment during sediment cleaning	Entrainment and impingement onto fish screens	Stressor/Facto r
Juveniles - Sacramento River –Delta	Juveniles - Sacramento River –Delta	Juveniles - Sacramento River –Delta	Life Stage (Location)
Juvenile migration and rearing - Oct - April	Juvenile migration and rearing - Oct - April	Juvenile migration and rearing - Oct - April	Life Stage Timing (Work Window Intersection)
Injury or death due to impingement, capture by grappling hooks	Injury or death due to entrainment into dredge or impingement onto fish screens	Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Individual Response and Rationale of Effect
Minor to Lethal	Minor to Lethal	Minor	Severity of Stressor/ Level of Benefit
Small	Small	Small	Proport ion of Populat ion Expose d
Low. Aquatic weeds removed infrequen tly	Low. Sediment removed infrequen tly	High	Frequen cy of Exposur e
Low - fish unlikel y to be in area of	Low-fish unlikel y to be in area of screens during cleanin g	Low- screens are designe d for delta smelt criteria, few salmon ids expecte d to be present at screen locatio n	Magni tude of Effect Effect hydrod ynamic s
Low. No reports or studies available	Low. No reports or studies available	High - monitoring has few observation s of Chinook salmon at this location, multiple studies regarding efficiency of positive barrier fish screens	Weight of Evidence
Minimal decrease in fitness	Minimal decrease in fitness	Minimal decrease in fitness	Probable Change in Fitness

<u> </u>		
Delta	Delta	Division
Predator removal studies	CCWD Rock Slough water diversions	Action Compone nt
capture in sampling gear	routing	Stressor/Facto
Juveniles - Sacramento River –Delta	Juveniles - Sacramento River –Delta	Life Stage (Location)
Juvenile migration and rearing - Oct - April	Juvenile migration and rearing - Oct - April	Life Stage Timing (Work Window Intersection)
Increased vulnerability to injury and predation due to entanglement/ent rapment in sampling gear	Delayed migration and increased transit times with potential for increased mortality due to routing into the channel of Rock Slough where predation is likely to be elevated	Individual Response and Rationale of Effect  during weed removal
Sublethal to Lethal	Minor to Lethal	Severity of Stressor/ Level of Benefit
Small	Small	Proport ion of Populat ion Expose d
Low	High - pumping through the Rock Slough diversion occurs every year	Frequen cy of Exposur e
Low - infrequ ent sampli ng over two to three years of study	Low-small number s of fish are likely to be in the vicinity of the fish screens and intake	Magni tude of Effect Effect screens during cleanin
Medium - Several reports from previous predator removal studies, literature on sampling methods.	Medium - annual monitoring reports indicate that no fish are entrained through the screens, however some fish are observed in front of the screens, and have been observed in historical monitoring.	Weight of Evidence
Reduced survival	Reduced fitness due to delay in migration or increased predation.	Probable Change in Fitness

	and	migrat									
	through the	winter-				predators					
	increase transit time	tail end				increased					
	barriers	very				mortality due to					
	indicated	occurs				potential for	3				
	have	barriers				times with	April			al Barriers	
	studies	tion of				increased transit	rearing - Oct -	River -Delta		Agricultur	
survival	several	installa	(		to Lethal	migration and	migration and	Sacramento		Delta	
Reduced	Medium -	Low-	High	Small	Sublethal	Delayed	Juvenile	Juveniles -	transit times	South	Delta
	gates,					and blockages.					
	radial					migratory delays					
	Marsh					temporary					
	the Suisun					potential					
	delays at					Delta smelt,				on Studies	
	migratory					food supplies for				Distributi	
delays	assessed					River to improve	!			Food	
caused by	have					and Roaring	April			River	
to fitness	studies					Suisun Marsh	rearing - Oct -	River -Delta		Roaring	
reductions	several					flows entering	migration and	Sacramento	management	Marsh/	
Minor	Medium –	Low	Low	Medium	Minor	Management of	Juvenile	Juveniles -	Habitat	Suisun	Delta
	exposure										
	fish to CO2										
	of smaller										
	sensitivity										
	and										
	predators										
	of .					channel					
	ш тепюмат					secondary					
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	se of CO2					clean outs of					
	effectivene					during predator					
	show					CO2 exposure	April				
	studies					mortality due to	rearing - Oct -	River -Delta		ents	
fitness	several		()		to Lethal	morbidity and	migration and	Sacramento	5	Improvem	
Reduced	Medium -	Low	High	Small	Sublethal	Small increase in	Juvenile	Juveniles -	CO2 Injections	CVP	Delta
				d	ренен		THICE SECTION)				
			ď	Funcion	Devel of	Ellect	Tatagatian				
III F Itiless		FILECT	Exposur	r opulat	Suresson/	Radonale of	Window			ı	
in Fitness	PAIGENCE	Effect	Exposur	Populat	Strossor/	Pationals of	Work	(Location)	5	Compone	
Char	Evidence	tude of	ev of	ion of	of	Pesnonse and	Timing	(I ocation)	Direson/r acto	Compone	Division
Probable	Weight of	Maoni	Frequen	Proport	Severity	Individual	Life Stage	Life Stage	Stressor/Facto	Action	Division

				_		_										_				_			
Division									Delta								Delta						
Action Compone nt									Water								Fall Delta	smelt habitat					
Stressor/Facto									I ransit times								Habitat	management					
Life Stage (Location)									Juveniles - Sacramento	River –Delta							Juveniles -	Sacramento River –Delta					
Timing (Work Window Intersection)									Juvenile migration and	rearing - Oct - April							Juvenile	migration and rearing - Oct -	April				
Individual Response and Rationale of Effect									extension of water transfer	window to include October	and November – elevated flows	may reduce transit times	through riverine	waterways			Management of	salinity mixing zone to benefit	food production in fall in wet year	types – targeted	to Delta smelt but	may improve food resources	for salmonids in
Severity of Stressor/ Level of Benefit									: Low								Beneficial	: Low					
Proport ion of Populat ion Expose d									Small								Small						
Frequen cy of Exposur e									Low								Medium						
Magni tude of Effect	period, exposu re to the	the	is	expecte	d to be	minima			Low								Low						
Weight of Evidence	predation risks. Timing of winter-run	winter-run	Delta	channels is	well	documente	d by	records.	reports or	studies available	for this action –	other studies do	show	nt in	survival	river flows.	Uncertain -	effectivene ss of this	type of habitat	manipulati	on for	salmonids is uncertain	
Probable Change in Fitness									Increased								Uncertain	benefits -					

Overall, under the PA, there are 25 action components expected to create stressors for various life stages and 11 action components that benefit various life stages (Table 2.8.1-2).

Table 2.8.1-2. Summary of the number of PA actions expected to create stressors or benefits of varying levels of magnitude to various winter-run Chinook salmon life stages as identified in Table 2.8.1.-1..

Magnitude Level	Actions Creating Stressors Under the PA	Actions Creating Benefits under the PA
High ¹	8	5
Medium	6	4
Low	11.	2
Total ²	25	11

¹ If the magnitude was a range that included "High" then that stressor or benefit was counted in the "High" category, and not recounted in the "Medium" or "Low" categories.

While the entire suite of adverse and potentially beneficial effects associated with the PA are described in Section 2.5 and summarized in Table 2.8.1-1 above, and are considered in the jeopardy analysis, focus is placed on water temperature management, low Sacramento River flows during the fall and winter, DCC routing, and south Delta export operations, because among all the PA components, those have the largest effects on winter-run Chinook salmon viability. NMFS has also focused on the beneficial or potentially beneficial actions included in the PA to evaluate their potential for offsetting some of the operational effects.

Our analysis of baseline conditions with respect to temperature management shows that providing cold water in the Sacramento River to protect winter-run Chinook salmon eggs and alevins is perennially a management challenge. Even in wet years, the cold water pool in Shasta Reservoir must be carefully managed to provide protective water temperatures for winter-run Chinook salmon eggs and fry on the valley floor throughout the summer and early fall. As previously described, releases of warm water from Shasta Reservoir contributed to early life stages of winter-run Chinook salmon to suffer 85 percent mortality in 2013, followed by 94 percent mortality in 2014, followed by 96 percent mortality in 2015 (Swart 2016). It has long been recognized that prolonged drought could extirpate the entire winter-run Chinook salmon ESU, if its effects persisted for four or more years (Lindley et al. 2007). The future occurrence of a drought that long is all but inevitable given that droughts of at least four years have occurred in the past (Steinbeck 1952, Cook et al. 2004), and a growing body of evidence suggests that climate change has increased the likelihood of extreme droughts in California (Department of Water Resources 2018). It is worth noting that prior to Shasta Dam winter-run Chinook salmon persisted through prolonged droughts by spawning in the high elevation, cold water spring-fed rivers upstream from the impassable Shasta and Keswick dam complex. These high elevation habitats have been inaccessible to salmon since the late 1930s when construction of Shasta Dam

² If the magnitude was identified as "Uncertain" or "NA", then that stressor or benefit was not counted. The water temperature stressor was only counted once for its impact on eggs even though there are four "High" magnitude stressor rows for that stressor-life stage combination, because each row corresponds to a different tier and not an additional stressor or life stage impacted. Similarly, the "High" magnitude beneficial actions related to the single issue of water temperature planning were counted once.

was started. Upstream of Shasta Dam, large quantities of historical habitat are managed by state and federal agencies and private forestland owners engaged in land management activities have helped to maintain, and in many cases improve, watershed conditions. These historical habitats possess suitable spawning, holding, and rearing habitat, even during drought conditions. Access to historical habitat upstream from Shasta Dam would improve population spatial structure and diversity, increasing the viability of the ESU. An action to reintroduce fish to their historic habitat upstream of Shasta Reservoir was included in the 2009 RPA and pilot studies are ongoing, but will not be carried forward as part of the PA.

The effects analysis presented in the BA is a comparative analysis that shows that egg mortality under the PA is generally less than under the COS. Figure 2.8.1-1 gives the exceedance curves for the water-temperature related egg-to fry-mortalities under the PA and COS scenarios. Separate results are given for the Martin et al. (2017) and Anderson (2018) modeling. Differences between the Martin and Anderson model results are generally small. For both models, the PA mortalities are less than the COS mortalities for the majority of years in all water year types, with some lower performance in some above-normal water-year types.

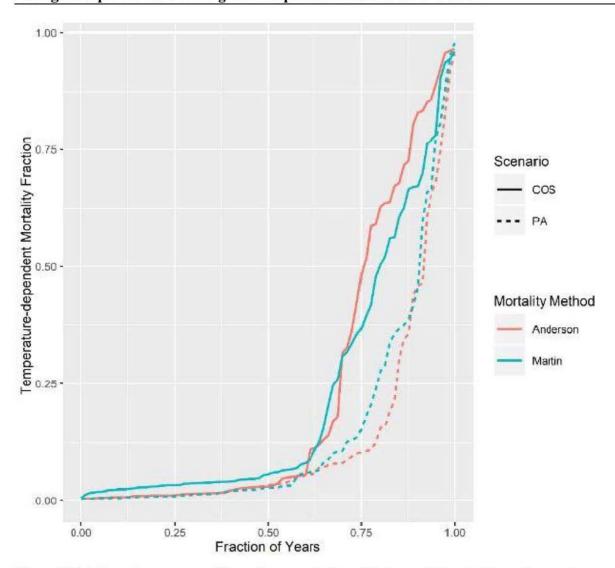


Figure 2.8.1-1. Exceedance curves of Upper Sacramento River Winter-run Chinook Salmon Temperature-Dependent Egg to Fry Mortality for All Water Year Types (modified from Figure 5.6-21 in the BA).

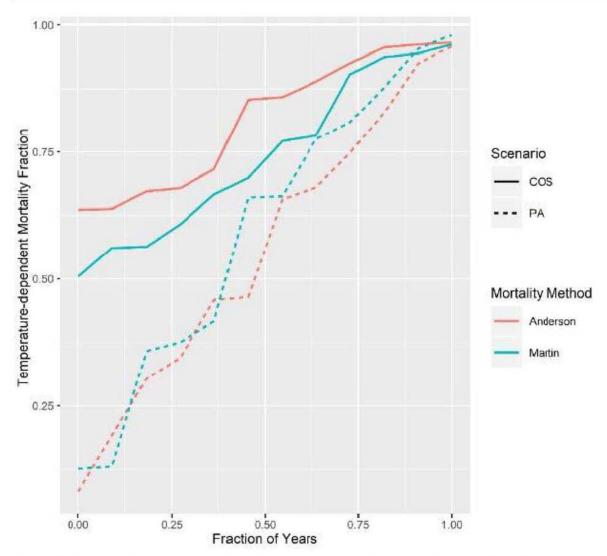


Figure 2.8.1-2 Exceedance curves of Upper Sacramento River Winter-run Chinook Salmon Temperature-Dependent Egg to Fry Mortality for Critically Dry Water Year Types (modified from Figure 5.6-22 in the BA).

Under critically dry conditions, the PA continues to outperform current operations, with up to 40 percent less mortality under the PA in some critically dry years (Figure 2.8.1-2). The BA on page 5-28 attributes improvements in temperature-dependent mortality under the PA to the proposed optimization of water temperatures early in the year leading to significant October improvements in temperatures: "the proposed action optimization of water temperatures early in the year leads to significant October improvements in temperatures driving these large improvements in temperature dependent mortality in wetter critically dry years."

It is not entirely clear in the BA, but this statement likely relates to the PA's ability to build Shasta Reservoir storage and coldwater pool availability such that 53.5°F to the Sacramento River-Clear Creek gauge (CCR) throughout the PA's winter-run Chinook salmon temperature management window will be achieved 68 percent of all years. As described in Shasta Annual

Operations (Section 2.5.2.1) Reclamation has committed to four operational actions that are designed to build storage. These are: (1) minimum late fall and winter flows, including modification of rice decomposition operations compared to the COS; (2) modified fall outflow requirements compared to the COS; (3) flexibility in export operations (especially in April and May) compared to the COS, and anticipated improved salinity conditions which would reduce carriage water demands; and (4) December 2018 changes to COA (which are also included in COS). As described in Table 2.5.2-2 in Section 2.5.2.1 Effects of the Action, there is a general lack of certainty regarding the effects of these operations to build storage and provide temperatures suitable for salmon holding, spawning, egg incubation and rearing from May to October.

Another aspect of water temperature optimization under the PA is an egg hatch protection operation proposed in tiers 2 and 3, in which the period of cold water releases from the reservoir for winter-run Chinook salmon protection could be reduced from over five months to as short as three months following the approach described in Anderson (2018). This reduction in the water temperature management window is based on the concept that eggs are most sensitive to low dissolved oxygen and warm water temperatures for five days previous to the hatching period. So, as long as the period of egg hatching is protected by achieving 53.5°F at CCR, overall egg-to-fry survival could be comparable to protecting the entire egg incubation and alevin development time period with 53.5°F at CCR. While there may be promise in this concept, the premise of being able to provide equal or better protection to winter-run Chinook salmon eggs by using less cold water is speculative at this point.

Managing an endangered species with this approach is premature and gives NMFS great concern for two main reasons. First, the hatch protective operation in the PA is based on a nascent concept that is unpublished³⁰, has not been scientifically peer reviewed, and has not been tested in the laboratory. More scientific support for the hatch protection operation is needed, at least laboratory testing, before using it as a management tool. Second, the approach relies on a nearperfect understanding of egg incubation timing in the field on a time scale of days - if redds are not detected right away either early or late in the spawning season, then the eggs in those redds would not be fully included in the cold water releases (53.5°F at CCR) made for the hatch protection operation, and would likely be exposed to lethal water temperatures. For early season detection in applying the hatch protective operation, aerial redd survey flights occur once per week and their effectiveness is limited by water clarity and redd depth, and as such temperature protection could be delayed by 7 days or more. The use of carcass surveys for early season detection would likely result in delayed protection as well given that spawning occurs roughly 10 days before carcass detection. Considering that egg mortality increases at water temperature above 53.5 °F (Martin et al. 2016), any water temperature exposure that occurs outside of the hatch protection window, would likely have sublethal and lethal impacts on salmon eggs.

Additionally, under the PA in all years (not just the tier 2 and 3 hatch protective operation years), late-emerging winter-run Chinook salmon alevin would be at risk as water temperature management achieving 53.5°F at CCR would only occur until 95 percent of the alevin have emerged, or October 31, whichever comes first. The PA does not indicate how it would make that determination and current monitoring is not informative for such a determination.

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³⁰ Anderson (2018) is available for download through the social networking site ResearchGate.

While the comparative COS to PA modeling results suggest that the PA would protect winter-run Chinook salmon eggs better than under current operations, NMFS considers these results to be inconclusive based on the rationale provided above and in the Upper Sacramento River effects analysis section. In the integration and synthesis, NMFS considers the full effects of the PA water operations to winter-run. From this perspective, the PA, while it may increase storage relative to the COS, is nonetheless expected to result in concerning levels of mortality. Specifically, operations under the PA are expected to expose winter-run Chinook salmon to lethal water temperatures that would result in mean mortality of 5 to 6 percent for 45 to 68 percent of years (Tier 1), 12 to 15 percent mortality for 17 to 35 percent of years (Tier 2), 28 to 34 percent mortality for 7 to 15 percent of years (Tier 3), and 79 to 81 percent mortality for 5 to 7 percent of years (Tier 4).

Revisions to the Cold Water Pool Management section of the final PA include the addition of Section 4.10.1.3.3 Upper Sacramento Performance Metrics. The objective of these performance metrics is to ensure that the performance falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of the PA. This addition to the Cold Water Pool Management section contributes to increasing the certainty that the central tendency of the analyzed results is what the species will experience when these operations are implemented. That is, the analysis characterized exposure and risk based on the central statistics of modeled TDM for each Tier type and the long-term projected likelihood of occurrence of each year type. However, the TDM results included a broad range for each Tier due to the variability of conditions included in each Tier type. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which is based on the central tendency to capture the most likely conditions – to be a more accurate characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management do not change quantitatively due to the revisions included in the final PA, as this commitment to assess cold water management does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

During drier water years with operational conditions as described in the Tier 3 and Tier 4 scenarios and as requested by NMFS in furtherance of meeting Sacramento River performance objectives, the SRS Contractors will meet and confer with Reclamation, NMFS and other agencies as appropriate to determine if there is any role for the SRS Contractors in connection with Reclamation's operational decision-making for Shasta Reservoir annual operations in those years. This determination will include consideration of what actions are feasible, consistent with the terms of the SRS Contracts and would also effectuate the desired outcome. The commitment from the SRS Contractors to meet and confer during Tier 3 and Tier 4 years, as requested, further decreases the uncertainty associated with high mortality values modeled for Tier 3 and Tier 4 years. NMFS expects that any actions taken would increase the likelihood that resulting mortality values would be minimized to the extent possible and may also help build fall storage in Shasta Reservoir.

Table 2.8.1-3. Observed winter-run Chinook salmon egg-to-fry mortality, calculated using the estimated egg-to-fry survival to the Red Bluff rotary screw traps (100 minus estimated survival).

Year	Egg-to-Fry Mortality (%)
2002	54
2003	74
2004	79
2005	75
2006	82
2007	76
2008	86
2009	64
2010	68
2011	61
2012	80
2013	87
2014	96
2015	97
2016	76
2017	56

Table 2.8.1-4. Total egg mortality expected under the proposed action.

		Martin Model			Anderson Model	
Tier	Mean	Min	Max	Mean	Min	Max
1	70	68	80	70	68	82
2	73	68	83	72	68	83
3	79	70	93	77	70	89
4	94	87	99	93	88	99

It is uncertain whether winter-run Chinook salmon can be sustained over the long-term with the levels of egg mortality expected under the PA, especially with the inevitability of droughts, which are expected to increase in frequency, duration, and severity with climate change (Department of Water Resources 2018) (see section 2.4.1.5 Climate Change for a more complete discussion of climate change). The added risks of predicted temperature related effects in aggregate with the baseline stressors contributing to total mortality as modeled under the PA (Table 2.8.1-4) and as measured at the Red Bluff rotary screw traps (Table 2.8.1-3) increases the risk to the long-term survival of this species. We do consider the project components that are intended to offer as much protection as practicable in drought or extreme conditions, including the process for development of an annual temperature management plan, the use of conservative forecasts, protection of the third cohort after two consecutive years of poor survival, and specific "at the ready" actions for drought and dry years. The temperature management plan may reduce

the likelihood of exceeding the temperature target, which is used in the characterization of exposure to increased temperatures in the analysis. The conservation measures intended to protect the third cohort of winter-run Chinook salmon after two consecutive years of poor survival are critical to sustaining the population, and are intended to allow opportunities for actions to be implemented to protect species despite the probability of year types that may occur. Finally, NMFS expects a reduction in extreme effects on the species throughout extended drought due to the Drought and Dry Year Actions. We note the potential benefit of a toolkit of actions to be taken in drought conditions, and the process by which early warnings of drought conditions may allow for clear and swift development of a drought contingency plan. We also note that the action to reintroduce fish to their historic habitat upstream of Shasta Reservoir included in the 2009 RPA that is not being carried forward as part of this PA would be an important addition to the tool kit to help the species withstand droughts.

The next key stressor to winter-run Chinook salmon that will result from PA implementation addressed here is fall and winter refill and redd maintenance. Under that PA component, in years with the lowest Shasta Reservoir storage at the end of September, flows will be reduced to 3,250 cfs in the fall, winter and spring to build storage. These flow reductions are expected to limit access to food rich floodplain habitat and reduce juvenile survival during rearing and downstream migration. A recent assessment of mark-recapture survival models in the Sacramento mainstem revealed that of the numerous mortality factors considered, spanning multiple spatial scales, flow correlated the strongest with out-migration success (Iglesias et al. 2017). This assessment focused on hatchery origin Chinook salmon, but it provides additional evidence that flow is one of the most important factors affecting overall survival of Chinook salmon in the Central Valley (Kjelson and Brandes 1989, Zeug et al. 2014, Michel et al. 2015). Likewise tagging data comparing 2015 to 2016, that included both CV spring-run Chinook salmon and fall-run Chinook salmon, showed faster migration times and higher survival correlated to the higher flow conditions in 2016 (Cordoleani et al. 2018). Overall, juvenile mortality during out-migration to the ocean is considered a critical phase to overall population dynamics (Williams 2006), and recent evidence suggests that winter-run outmigration survival, and the conditions that affect it, are the primary drivers of smolt-to-adult ratio (SAR) dynamics (Michel 2018). Recent conditions in the mainstern Sacramento are such that a review of coded wire tag recovery data for hatchery origin winter-run, late-fall-run, and fall-run Chinook salmon, showed annual SAR estimates below 1 percent. For winter-run the mean SAR from 1999 to 2012 was 0.64 percent (SE 0.18), well below the Columbia River Basin Fish and Wildlife Program suggested minimum of 2 percent SAR required for population survival and 4 percent for population recovery for Upper Columbia River and Snake River Chinook salmon populations (Michel 2018). These Chinook salmon SAR benchmarks for survival and recovery, while developed for Columbia and Snake river Chinook salmon populations, are independent of factors such as river location and size, so can provide general context for Sacramento River winter-run Chinook salmon SAR. Therefore, while reducing reservoir releases helps build storage for the following temperature management season, doing so also has a negative effect on downstream migration and survival. The resultant fall and winter flows under the PA are expected to be lower than what occurs under current operations, exacerbating winter-run SAR, estimates of which are already below population survival and recovery benchmarks under baseline conditions.

The poor juvenile survival expected under the PA due to low fall and winter flows will more than likely occur on a cohort that already experienced low survival during egg incubation given

the positive relationship between end of April and end of September storage (Figure 2.5.2-3). When end of April storage is less than 3.5 MAF, TDM will correspond to Tier 3 or Tier 4 levels and there is a high likelihood that end of September storage will be less than 2.2 MAF, triggering flow reductions to 3,250 cfs. Thus, the same cohort will likely experience both low egg to fry survival and low out-migration survival.

The third component affecting winter-run Chinook salmon survival covered in this section is the potential increase in DCC routing that could occur under the PA. Under the modeled PA conditions, the DCC gates are expected to be opened more during October and November which could increase the exposure of early-migrating winter-run Chinook salmon to the risk of routing into the DCC waterway. Revisions to the PA not captured in the modeling include the potential for increased fall flows in Above Normal and Wet years for the Fall Delta Smelt Habitat Action, which might reduce the DCC openings under the PA in October and November. The PA also allows for the DCC to be opened for up to 10 days during December through January for water quality concerns (compared to up to 3 days for water quality concerns, and some possible openings for experiments, under the COS). However, revisions to the PA clarified that these December through January DCC openings would be limited to occasions when drought conditions are observed (defined as 90 percent exceedance hydrology) and gate opening will help to address water quality concerns -- expected to occur less than 10 percent of the time. The revised PA also included a new commitment to reduce combined CVP/SWP exports to health and safety levels (1,500 cfs) during any DCC gate opening in December or January. During December and January, approximately 50 percent of winter-run population will be in the vicinity of the DCC gates where they will be at risk of entrainment into the DCC waterway, but that risk is expected to be realized in less than 10 percent of years. Over the full October through January time period, a substantial proportion of the juvenile winter-run Chinook salmon cohort is expected to pass the DCC.

As described in section 2.5.6.2.4 Assess Response of Species to the Proposed DCC Gate Operations, fish that move downstream through the DCC or Georgianna Slough enter the migratory routes through the Delta interior and are subject to a much lower rate of survival. In addition, reduced flows downstream of the open DCC in the main stem Sacramento River would be expected to reduce survival due to increased transit times and the potential to be entrained into Georgiana Slough.

The general findings of the WRLCM and the DPM for winter-run Chinook salmon migrating through the Delta show reduced survival of juveniles under the PA for Below Normal, Dry, and Critical water year types, and only slightly higher survival for Wet and Above Normal water year types, relative to the COS.

Based on results of the Perry Survival Model, juvenile winter-run entering the Delta from the Sacramento River in October or November will have a greater risk of being routed into the Delta interior through open DCC gates associated with lower Delta inflows under the PA compared to the COS (Figures 2.5.5-7, 2.5.5-11). These routes have the potential to have longer travel times through the Delta for the PA compared to the COS (Figures 2.5.5-8, 2.5.5-10), which in turn is expected to create conditions that have lower through-Delta survival for migrating winter-run Chinook salmon (Figures 2.5.5-6, 2.5.5-9). Based on the modeling, survival could be reduced up to approximately 10 percent (lower 25th percentile) during the October through November period in Wet, Above Normal, Below Normal, and Dry water year types. The reduction is less in

Critical water year types, when it would affect approximately 5 percent of the brood year population, based on historical fish monitoring. These effects result in part from efforts to increase Shasta Reservoir storage overall by reducing fall flows, and point to the challenges and constraints of managing this species for all life stages below Shasta Reservoir.

The last major PA component affecting winter-run Chinook salmon survival is the action of pumping water from the south Delta export facilities and the associated effects of the fish salvage operations. As discussed in the Environmental Baseline section, there is wide recognition that the baseline condition is such that Delta flows and habitats do not support native fishes and south Delta exports have played an important role in establishing that condition (California Department of Fish and Game 2010b, State Water Resources Control Board and California Environmental Protection Agency 2010, Hanak et al. 2011, State Water Resources Control Board 2017b). The February 5, 2019 PA (Appendix A1) would increase south Delta water exports relative to current operations (COS) (Figure 2.8.1-3) and results from the Salvage Density Model indicate increased winter-run Chinook salmon loss under the February 5, 2019 PA (Appendix A1) (Table 2.8.1-5). The loss estimates presented in Table 2.8.1-5 do not include loss due to louver cleaning, predation observed to occur on the upstream side of the TFCF trash racks (Vogel 2010), or far-field predation associated with altered hydrodynamics, and therefore underestimate mortality associated with south Delta pumping and fish salvage operations.

While loss is still expected to occur under the final PA, NMFS notes that the revised loss thresholds in the June 14, 2019 PA are expected to limit risks associated with the near-field effects (entrainment into and loss at the export facilities) to levels less than estimated using the Salvage Density Model results described in Section 2.5.5.8.3.1, and to levels comparable to loss observed under the COS. The final PA includes triggers for review and technical assistance anytime observed loss exceeds average annual historical loss, which provide some assurance that species risks will be conservatively managed. The Salvage Density Model shows the greatest differences in the PA vs. the COS during April and May, when winter-run have largely exited the Delta, but the revised loss thresholds for both natural and hatchery winter-run are expected to provide an incremental level of additional protection relative to the original PA. Even under the revised PA, thousands of juvenile winter-run Chinook salmon are expected to die in most water year types due to direct loss (Table 2.8.1-5, using the COS results as a proxy for direct loss expected under the revised PA), which includes pre-salvage mortality from both pre-screen loss and imperfect fish guidance efficiency at louvers or screens. Far-field mortality associated with south Delta pumping and fish salvage operations is also expected under the final PA. It is less certain whether the revised loss thresholds in the final PA will fully limit risks associated with the far-field effects (potential disruptions to migration rate or route) of the export facilities that may lead to mortality. Because NMFS assumes that far-field effects are correlated with exports (both footprint and magnitude of hydrodynamic effect greater at higher exports), limiting nearfield effects to historical rates could be assumed to limit far-field effects to historic rates. However, if OMR (and associated Delta hydrodynamics) is more negative under the final PA than observed under the COS, far-field effects under the final PA are expected to be intermediate between the COS and the original PA. Because exports and associated OMR flows in the original PA and COS scenario are more similar during December-March than in April-May, farfield effects intermediate between the COS and the original PA are most likely to affect winterrun migrants that do not exit the Delta by the end of March.

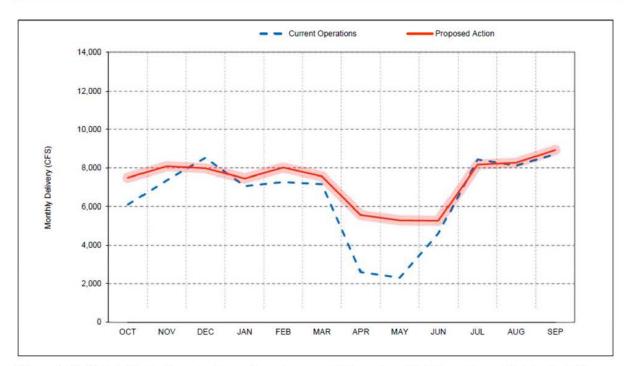


Figure 2.8.1-3. Total Delta Exports, Long-Term Average Delivery (modified from Figure 53-1 in the BA). Results are with calendar year sorting. Scenarios are simulated at Early Long-Term Q5 with 2025 climate change and 15 cm sea level rise. Revised loss thresholds in the June 14, 2019 PA may result in lower exports than as modeled in the February 5, 2019, BA, but NMFS expects that exports in April and May will remain higher than in the COS.

Table 2.8.1-5 Estimated Juvenile winter-run Chinook salmon loss (using the Salvage Density Model) for the PA and COS scenarios at the CVP/SWP fish salvage facilities by water year type, based on February 5, 2019, PA.

Water Year Type	PA	COS	PA-COS	% change
Wet	13,788	12,417	1,371	11
Above Normal	6,806	6,369	437	7
Below Normal	6,812	5,831	981	17
Dry	5,071	4,105	966	24
Critical	1,702	1,231	471	38

The expected increase in juvenile mortality under the PA as a whole, while reduced by the revised loss thresholds, exacerbates the baseline condition in which freshwater survival of Central Valley Chinook salmon smolts is already relatively low compared with Chinook salmon smolt survival from the Columbia and Frasier rivers, in spite of those rivers having substantially longer migration corridors (Michel et al. 2015). Further, as previously discussed, winter-run outmigration survival, and the conditions that affect it, are the primary drivers of SAR dynamics, and marine survival likely plays a critical role only in years with abnormally unfavorable marine conditions for salmon (Michel 2018). With this understanding and context regarding the importance of outmigration survival to overall population productivity, the expected decrease in

juvenile survival associated with Delta exports and low Sacramento River flows under the PA is expected to increase winter-run Chinook salmon extinction risk.

In summary, the June 14, 2019 PA revisions reflected in the final PA (Appendix A3) regarding OMR management and performance objectives intend to limit loss to levels less than estimated using the Salvage Density Model results described in Section 2.5.5.8.3.1, and to levels comparable to loss observed under the COS. Achieving those OMR management objectives likely would offset the expected increase in winter-run Chinook salmon extinction risk associated with loss under the February 5, 2019, BA. However, as described in section 2.5.5.11.1, there are some uncertainties in how this new approach will be implemented and uncertainties associated with far-field effects. Given the recent increased knowledge regarding the importance of freshwater survival in driving population dynamics and the fact that winter-run SAR is below a benchmark for population survival (Michel 2018), it is not clear whether the objectives will offset both near- and far-field effects enough such that juvenile survival will be sufficient for population survival, or the objectives will effectively contribute to the continued maintenance of juvenile survival at unsustainable levels. What is clear is that the south Delta exports under the revised PA will continue to result in winter-run Chinook salmon mortality and are still considered an important stressor.

High magnitude beneficial actions of the PA include:

- The small screen program component. This is a framework level programmatic component with very little information available as to how it would be implemented or its effects when operated, and as such has a low certainty associated with its characterization as a high magnitude beneficial component. Therefore, while we cannot rely on the beneficial effects of this component in this opinion to offset adverse effects, a more specific proposal received at a subsequent date could be beneficial.
- The Wilkins Slough Intakes component. This is a framework level programmatic
  component with very little information available as to how it would be implemented or its
  effects when operated, and as such has a low certainty associated with its characterization
  as a high magnitude beneficial component. Therefore, while we cannot rely on the
  beneficial effects of this component in this opinion to offset adverse effects, a more
  specific proposal received at a subsequent date could be beneficial.
- Operation of a carbon dioxide injection device to clear predators from the secondary channel in the TFCF on a regular basis. Reducing the predator density within the secondary channels is expected to enhance juvenile winter-run Chinook salmon survival through the TFCF by reducing predation on fish passing through the secondary channel to the holding tanks. The magnitude impact of this action has a medium certainty.
- Shift in exports to CVP from SWP to reduce impacts of predation from the CCF when
  capacity at CVP exists. The magnitude impact of this action has a medium certainty
  given the uncertainty associated with the availability of capacity at the CVP to shift
  exports.
- The SRS Contractors Recovery Program will result in benefits to spawning success and production associated with increasing the quantity and quality of spawning substrate in the upper Sacramento River; benefits to rearing and migrating juvenile fish associated

with the installation of fish screens and the construction of side-channel and in-channel habitat structures; and benefits to adult migrants and rearing and migrating juvenile fish from the construction of fish passage projects. The magnitude impact of these actions has a medium to high certainty based on past performance of the SRS Contractors Recovery Plan since 2000.

 The SRS commitment to the scope, mission and objectives of the Sacramento River Science Partnership is expected to improve the science that is used to protect and support the recovery of winter-run Chinook salmon.

Additionally, the LSNFH tier 4 intervention measure, accelerating the Battle Creek restoration, and Sacramento River spawning and rearing habitat restoration components of the PA could help offset adverse impacts of the PA, particularly if more specific proposals are developed. As described in section 2.5.2.6 Supplemental Analysis of Shasta/Upper Sacramento Division, late revisions to the PA include improvements to LSNFH cold water reliability, water treatment, fish trapping, and overall capacity, which will help reduce risks to hatchery operations particularly during drought. However, in a consultation meeting on June 25, 2019, Reclamation indicated that the PA does not commit to implementing the Battle Creek action component, much less to accelerating the action. Rather, Reclamation would consider the benefits of this action as one of several options as a possible measure to be taken to improve cold water pool availability.

Habitat restoration occurring as part of the environmental baseline and the PA is expected to help winter-run Chinook salmon withstand adverse effects of the PA. The pace of Sacramento River habitat restoration has been high in recent years with multiple projects being completed annually due to a strong partnership among the Northern California Water Association, the Western Shasta Resource Conservation District, the Sacramento River Forum, Chico State University, local landowners, and the five agency family of CDFW, DWR, NMFS, USFWS, and Reclamation. Recently completed projects include gravel augmentation at Keswick and Market Street; side channel restoration at Painter's riffle, Cypress Avenue (north), and Lake California; and the placement of rearing habitat structures at North Tobiasson, and there are several similar projects in the conceptual, planning, or construction phases currently. The projects occurring under this Sacramento River habitat restoration partnership, the Yolo bypass fish passage improvement project, and efforts to restore Delta habitat give promise for crossing a tipping point where a positive species response trend emerges, but until that point is reached, we cannot assume that it will be reached, especially when the overall effect of the PA is expected to reduce the viability of the ESU. It is also worth noting that the potential benefits to viability from habitat restoration are likely constrained by managing a species that evolved for thousands of years with high elevation habitat characteristics such as steep gradient, high complexity, and consistent cold water in a valley floor tailwater.

### 2.8.1.3 Assess Risk to the Population

NMFS assesses the risk to the winter-run Chinook salmon population expected to occur with implementation of the PA by evaluating how the collective suite of PA factors and stressors is expected to impact the VSP parameters and the habitat capacity and diversity supporting population viability (see Figure 2.1.3-7). Under the VSP concept, population viability is determined by four population parameters: abundance, productivity (growth rate), spatial structure and diversity. Both population spatial structure and diversity (behavioral and genetic)

support a population's ability to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Habitat capacity and diversity form the base supporting population diversity and spatial structure. Thereby, the availability, diversity, and utilization of properly functioning habitats and the connections between such habitats provides the foundation for a viable, resilient population (Figure 2.4.1-3) (McElhany et al. 2000, Herbold et al. 2018). Below, the PA's impact on the VSP parameters for winter-run Chinook salmon are discussed in turn.

### 2.8.1.3.1 Abundance

As summarized above in section 2.8.1.2, and fully described in section 2.5 Effects of the Action, the PA will impose stressors in the Sacramento River and Delta that will decrease the abundance of winter-run Chinook salmon. The PA is expected to limit population abundance by exposing eggs to lethal water temperatures, exposing juveniles to lower Sacramento River flows during the fall and winter, entraining juveniles into the central Delta through the DCC, entraining and impinging juveniles at the Federal and State fish salvage facilities (near-, mid-, and far-field mortality), and processing all salvaged juveniles through the CHTR program. NMFS considers the IOS Model and winter-run Chinook Salmon Life Cycle Model (WRLCM) lines of evidence to evaluate effects in a life cycle context (Section 2.5.9 Life Cycle Models). While both models are comparative in nature, and therefore limited to the integration and synthesis, NMFS notes that results from the WRLCM support that expectation by indicating that abundance under the PA would be 3 percent lower than under current operations. IOS results show that adult escapement is nearly equal for the PA and the COS.

### 2.8.1.3.2 Productivity

Winter-run Chinook salmon productivity (population growth rate) is evaluated using trends in spawner abundance (Lindley et al. 2007), specifically focusing on the rate of decline in spawner abundance. The rationale behind the population decline criteria are fairly straight forward: severe and prolonged declines to small run sizes are strong evidence that a population is at risk of extinction. Population growth (or decline) rate is estimated from the slope of the natural logarithm of spawners versus time for the most recent 10 years of spawner count data. High extinction risk under these criteria are defined as a population declining within last two generations to annual run size less than or equal to 500 spawners, or a run size greater than 500 but declining at greater than or equal to 10 percent per year; moderate risk is a population undergoing chronic decline or depression such that the run size has declined to less than or equal to 500, but has stabilized; and low risk is when no decline in run size is apparent (Lindley et al. 2007).

It is likely that the reductions in abundance at the egg and juvenile life stages under the PA previously discussed would constrain year class productivity, but given the inherent variability in population abundance over time, it is difficult to infer how the PA's impact on population growth or decline relate to the productivity criterion in Lindley et al. (2007) in an absolute context. No such inferences are made here.

However, as described in Section 2.5.9.2.1.3 Assessment of Population Decline Criteria, the WRLCM allows for a comparative analysis between the PA and COS relating to the productivity criterion. To assess the relative probability of events in which next year's spawner abundance

will drop by at least 10 percent - indicating high extinction risk based on the productivity criterion - the WRLCM was run for 1,000 iterations to represent multiple "states of nature." In each of the model iterations, four different time lags (X = 1, 4, 12, or 20 years) were incorporated to calculate whether the abundance X years in the future had declined by 10 percent or more. For a given iteration, the number of events with population declines of 10 percent or more are assigned into three possible categories: (1) the number of events where abundance decreased by 10 percent or greater was higher in the COS than the PA, (2) the number of events were equal, or (3) the number of events were higher under the PA than the COS. The probability of each outcome was then calculated as the number of outcomes in each of the three categories divided by the total number of iterations, i.e., 1,000. This analysis does not indicate that there is a specific probability of a decline occurring under each scenario, but instead it indicates that over the 75-year timeframe (years 5 to 79), there is a higher probability of events in which next year's spawner abundance will decline relative to the number of events under the other scenario. The results presented in Table 2.5.9-1 indicate that the PA consistently has a higher probability of triggering high extinction risk for the productivity criterion than the COS for all four time lags evaluated.

It is important to note that applying the extinction risk criterion identified in Lindley et al. (2007), as was done to assess population productivity, does not mean the PA must achieve low extinction risk in order to ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species. Nor does it mean the PA must increase population viability on the level of an ESA listing status change (e.g., endangered to threatened) in order to avoid jeopardy. We are not applying recovery or ESA listing status bars to our jeopardy analysis. The analytical approach section describes the information considered and steps taken in order to perform a jeopardy analysis. Applying the productivity extinction risk criterion as we have done is informative from a comparative sense to see if the PA or COS affect extinction risk differently. The WRLCM-based analysis of the productivity criterion indicates that the PA is likely to increase winter-run Chinook salmon extinction risk more than the COS.

Another measure of population productivity is the cohort replacement rate (CRR). The observed CRR assuming all winter-run Chinook salmon return to spawn at age 3 and including hatchery origin spawners has fluctuated over the last 20 years (Figure B-3). CRR was negative for about half of that time period, with many of the negative CRR years occurring over the last decade. Seven out of the last 10 years have had a negative CRR indicating that the winter-run Chinook salmon population has not been consistently replacing itself under the baseline condition. Results from the winter-run Chinook salmon life cycle model indicate nearly identical CRR estimates for the PA and COS, with the PA being 0.5 percent higher than the COS. Piecing the observed CRR information together with the modeled CRR results indicating little difference between PA and COS suggests that PA implementation is likely to continue the baseline condition in which the winter-run population has not been consistently replacing itself.

### 2.8.1.3.3 Spatial Structure

As described in section 2.5 and summarized in Table 2.8.1-1, habitat conditions in the Sacramento River and Delta are negatively affected by the PA in a number of ways, including but not limited to (1) releasing lethal water temperatures for eggs in nearly all years, resulting in particularly high mortality in drier years; (2) decreasing flows during the juvenile rearing period, which increases the likelihood that juveniles using floodplain and side-channel habitats when

flows are high will be isolated from the river when flows are decreased; and (3) increased exports during April and May which increases direct loss at the south Delta export facilities and also creates hydrodynamic conditions expected to result in detrimental outmigration conditions and decreased survival by increasing the exposure of juvenile winter-run Chinook salmon to predation and poor water quality. The reductions in habitat quantity and quality caused by the PA limit the population's spatial structure, which likely impacts the population's genetic and phenotypic diversity, thereby reducing the ability of winter-run Chinook salmon to respond to environmental change (McElhany et al. 2000, Herbold et al. 2018).

### 2.8.1.3.4 Diversity

The diversity of winter-run Chinook salmon continues to be limited as a result of the PA, and is likely to be further reduced by the proposed water temperature management approach and south Delta exports. The PA proposes to conserve cold water used for water temperature management in a manner that does not protect the full spawning and egg incubation duration (mid-April/mid-May through October). Under the PA, achieving a daily average water temperature of 53.5°F or less at CCR would start after May 15, or when the monitoring working group determines, based on real-time information, that winter-run Chinook salmon have spawned, whichever is later. Eggs deposited before May 15 (or downstream of CCR) would be exposed to lethal water temperatures given that mortality increases as water temperatures exceed 53.6 °F (Martin et al. 2017). As described earlier, given current aerial redd survey and carcass survey methods, redds may be constructed 7-10 days before spawning is detected, so Tier 2 and 3 implementation could be particularly harmful for the early part of the egg incubation life stage. Additionally, this approach could create selection pressure against spawning in deep water as aerial redd survey effectiveness is limited by redd depth. On the back end, water temperature management would end October 31, or when the monitoring working group determines based on real-time monitoring that 95 percent of winter-run Chinook salmon alevin have emerged, whichever is earlier. Any alevin in the gravel after October 31 or after the 95 percent emergence determination is made would be exposed to lethal water temperatures. These are the conditions described by Tier 1 operations, the PA's most protective tier for winter-run Chinook salmon spawning and egg incubation. However, in Tier 2 of Summer Cold Water Pool Management, the proposed duration of achieving 53.5°F or colder at CCR is narrowed with implementation of the hatch protection operation, and in Tiers 3 and 4, water temperatures will not be managed down to 53.5°F or colder at CCR during any part of the temperature management season. Constricting the window for successful winter-run Chinook salmon spawning and egg incubation decreases life history diversity and goes against the portfolio effect concept that is important for population resilience (Herbold et al. 2018).

The PA also reduces winter-run Chinook salmon life history diversity and population resilience through the south Delta export operations. The PA proposes to increase total exports during the period from January to June, and in particular during drier water year types. The most dramatic increases in the original PA occur during April and May, though the revised loss thresholds and multiple process steps in the final PA provide some assurance that species risks will be managed at a higher level of protection than under the original PA. Nonetheless, winter-run Chinook salmon juveniles migrating through the Delta in April and May would likely be exposed to altered hydrodynamic conditions caused by an increase in exports relative to current operations, resulting in higher salvage and associated mortality relative to juveniles emigrating before April.

A minimum of 5 percent of the population will be exposed to the increased exports, and potentially more depending on their location in the southern and western Delta waterways. Reduced survival of winter-run Chinook salmon emigrants in April and May constricts life history diversity and also has important implications for cohort productivity. Because the timing and quality of conditions in the Bay-Delta and marine environments are highly variable, a diverse portfolio of juvenile sizes migrating at different times increases the chances that some fraction of each annual cohort will be able to capitalize on suitable conditions in those environments (Herbold et al. 2018) SEP 2019.

Winter-run Chinook salmon diversity is further reduced under the PA by the proposed practice of increasing hatchery production during dry conditions. As described in the Environmental Baseline, this practice was utilized successfully to bolster abundance through the most recent drought - adult escapement through 2018 continues to meet the low extinction risk criterion for abundance (i.e., census population size of 2,500 adults). However, the increased hatchery production during the drought resulted in a mean of 66 percent hatchery origin spawners from 2016-2018, which exceeds the threshold of 50 percent hatchery origin spawners over one generation that is considered to present a high risk to population's genetic diversity (Lindley et al. 2007). Increasing hatchery production to shepherd winter-run Chinook salmon through drought presents a delicate population viability and management tradeoff between negatively impacting genetic diversity and positively impacting abundance.

The combined effect of increasing hatchery production during drought, and reductions in natural-origin survival resulting from the exposure of eggs to warm water temperatures and exposure of juveniles to potentially increased routing through the DCC and increased pumping at the south Delta export facilities over all water years is expected to increase the likelihood that the high extinction risk threshold for hatchery influence criterion is crossed. Hatchery-origin winter-run Chinook salmon have a survival advantage over their natural-origin counterparts in that they bypass water temperature-dependent mortality occurring in the river and they are released at relatively large sizes, making them more likely to move through the Delta quickly, which reduces their susceptibility to predation and entrainment at the export facilities. This survival advantage favors an increase in the proportion of hatchery-origin fish returning to spawn, which contributes to lower diversity and higher extinction risk under the hatchery influence criterion (Lindley et al. 2007).

### 2.8.1.4 Assess the Risk to ESU/DPS

The risk to the winter-run Chinook salmon ESU posed by the PA is evaluated in the aggregate context of the effects of the PA itself, the species' status, the environmental baseline, cumulative effects, and effects from interrelated and independent actions. Because the winter-run Chinook salmon ESU is solely composed of one population, the effects of, and risks associated with, the PA at the population level described in the previous section (section 2.8.1.3) represent the risks at the ESU level as well. As discussed in that section, the effects of the PA are expected to reduce the viability of the ESU, which is already at high extinction risk, as described in the status and environmental baseline sections. The continued operation of the CVP/SWP as proposed in the BA does not improve the prospects for the ESU, and based on the effects and VSP-based analyses, would likely decrease the likelihood of survival and recovery.

The likelihood of survival and recovery would decrease not only due to additional stressors under the PA, but also because the transition from operating the CVP/SWP under the actions contained in the NMFS 2009 Opinion RPA (National Marine Fisheries Service 2009b) to the operations proposed in the ROC on LTO BA would remove measures that contribute to the ESU's survival and recovery. For example, this transition would reduce or eliminate protections against routing into lower-survival routes [RPA action IV.1.3 (engineering solutions and specifically a non-physical barrier at Georgiana Slough)] as well as the program to provide fish passage to and from historic habitats upstream from Shasta Dam (RPA action suite V). The recent drought was a stark lesson highlighting both the risk of managing winter-run Chinook salmon on the valley floor and the importance of restoring access to historic habitats that allowed the species to withstand prolonged droughts and persist for thousands of years.

The PA is expected to reduce the spatial structure, diversity, and abundance of winter-run Chinook salmon, further compromising the capacity of the ESU to respond and adapt to environmental changes. California's human population growth (see section 2.7 Cumulative Effects) and the associated increase in water demand and climate change, will exacerbate risks associated with the PA, further increasing the risk to the population and species.

Considering the effects of the PA, cumulative effects, and effects from interrelated and independent actions in the context of the status and environmental baseline of winter-run Chinook salmon, NMFS concludes that the PA is likely to appreciably reduce the likelihood of both the survival and recovery of the Sacramento River winter-run Chinook salmon ESU (Table 2.8.1-6).

Table 2.8.1-6 Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on Listed Species. Dark shading indicates selection. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and not likely/likely to jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if	True/False	Action
	The proposed action is not likely to produce stressors that have direct or indirect adverse effects on the environment	True	End
A	Available Evidence: The PA will produce multiple stressors that will adversely affect winter-run Chinook salmon including, but not limited to: warm water temperatures, low fall and winter flows in the Sacramento River, increased water routing through the DCC, and increased exports at the south Delta export facilities.	False	Go to B
	Listed individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the	True	NLAA
В	Available Evidence: The PA will expose individuals to multiple stressors, including but not limited to: (1) water temperatures warmer than life stage requirements during spawning, egg incubation, and juvenile rearing and outmigration; (2) low fall and winter flows in the Sacramento River; (3) increased entrainment into the central Delta through the Delta Cross Channel gates; and (4) increased entrainment at the south Delta export facilities.	False	Go to C

Step	Apply the Available Evidence to Determine if	True/False	Action
	Listed individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action  Available Evidence: The PA will produce multiple stressors that individuals	True	NLAA
С	will respond to, including but not limited to: (1) water temperature dependent egg mortality ranging from 6 to 88 percent, and sub-lethal effects due to warm water temperatures during the spawning, egg incubation, and juvenile rearing life stages; (2) reduced growth and survival associated with low fall and winter flows in the Sacramento River; (3) increased mortality associated with increased entrainment into the central Delta through the Delta Cross Channel gates; and (4) increased mortality associated with increased entrainment at the south Delta export facilities.	False	Go to D
	Any responses are not likely to constitute "take" or reduce the fitness of the individuals that have been exposed	True	NLAA
D	Available Evidence: The PA will produce multiple stressors, including but not limited to: (1) warm water temperatures; (2) low fall and winter flows in the Sacramento River; (3) increased water routing through the DCC; (4) and increased exports at the south Delta export facilities that are expected to reduce survival and the overall fitness of individuals which would result in "take."	False	Go to E
	Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent	True	NLJ
Е	Available Evidence: The combined effects of the PA are expected to sufficiently reduce the survival and/or reproductive success of winter-run Chinook salmon individuals at multiple life stages such that key population parameters (i.e., abundance, spatial structure, and diversity) will be appreciably reduced. Reductions in these parameters will likely reduce the viability of the population.	False	Go to F
	Any reductions in the viability of the exposed populations are not likely to reduce the viability of the species,	True	NLJ
F	Available Evidence: The winter-run Chinook salmon ESU is solely composed of the Sacramento River population. Therefore, because the viability of this population is expected to be reduced by stressors related to the PA, the viability of the species also is expected to be reduced.	False	LJ

### 2.8.2 Sacramento River Winter-run Chinook Salmon Critical Habitat

### 2.8.2.1 Status of Critical Habitat and Environmental Baseline

The action area encompasses the majority of the range wide riverine and estuarine critical habitat PBFs for winter-run Chinook salmon. Widespread degradation to these PBFs has had a major contribution to the status of the winter-run Chinook salmon ESU, which is at high risk of

extinction. PBFs (as discussed in the Section 2.2 Range-wide Status of the Species) include: (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River, (2) the availability of clean gravel for spawning substrate, (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, (4) water temperatures between 42.5 and 57.5°F (5.8 and 14.1°C) for successful spawning, egg incubation, and fry development, (5) habitat and adequate prey that are not contaminated, (6) riparian habitat that provides for successful juvenile development and survival, and (7) access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean. All of those PBFs can be characterized as suitable and necessary habitat features that provide for successful spawning, rearing, and migration. Therefore, the effect of the PA on critical habitat is evaluated in terms of its effect on spawning and rearing habitats and migratory corridors.

As described in sections 2.2 and 2.4 (Status of Species and Environmental Baseline), many of the PBFs that are essential for the conservation of winter-run Chinook salmon are impaired, and provide limited conservation value. For example, spawning habitat is impaired by the occurrence of water temperatures that cause egg mortality.

PBFs related to the rearing and migration of juveniles and adults have been degraded from their historical condition within the action area as well. Adult passage impediments on the Sacramento River existed for many years at the RBDD and ACID dam (National Marine Fisheries Service 2014b). However, the RBDD was decommissioned in 2012, providing unimpaired juvenile and adult fish passage, and a fish passage improvement project at the ACID was completed in 2015, so that adult winter-run Chinook salmon could migrate through the structure at a broader range of flows reaching spawning habitat upstream of that structure.

Juvenile migration corridors are impacted by reverse flows in the Delta that become exacerbated by water export operations at the CVP/SWP pumping plants. This impairs routing and timing for outmigrating juveniles and is evidenced by the presence of juvenile winter-run Chinook salmon at the State and Federal fish salvage facilities. The construction of the DCC created an artificial connection between the Sacramento River and the Delta interior. Fish routed into the Delta interior when the DCC gates are open have substantially lower survival rates than fish that remain in the Sacramento River migratory corridors. The DCC also impacts local hydrodynamics when it is open, reducing survival in downstream reaches of the Sacramento River due to tidal effects and reductions in flow remaining in the Sacramento River (Perry et al. 2015, Perry et al. 2018). Shoreline armoring and development has reduced the quality and quantity of floodplain habitat for rearing juveniles in the Delta and Sacramento River (Williams et al. 2009, Boughton and Pike 2013). Juveniles have access to floodplain habitat in the Yolo Bypass only during mid to high water years, and the quantity of floodplain available for rearing during drought years is currently limited. The Yolo Bypass Restoration Plan includes notching the Fremont Weir, which will provide access to floodplain habitat for juvenile salmon over a longer period (California Department of Water Resources and U.S. Bureau of Reclamation 2012), however, Reclamation clarified in a meeting on June 25, 2019, that there is no commitment to implement the project beyond current year appropriations, which limits NMFS' ability to incorporate the benefits of Yolo Bypass restoration in the analyses of this Opinion.

### 2.8.2.2 Summary of Proposed Action Effects on Critical Habitat

As described in section 2.5, the quantity and quality of spawning, rearing, and migration PBFs in the Sacramento River and Delta are negatively affected by the PA in a number of ways, including but not limited to (1) releasing lethal water temperatures for eggs in all years, resulting in particularly high mortality in drier years; (2) decreasing flows during the juvenile rearing period, which increases the likelihood that juveniles using floodplain and side-channel habitats when flows are high will be isolated from the river when flows are decreased; and (3) entraining more water and juvenile salmon into the central Delta through the DCC (primarily in October and November; there is a lesser effect in the final PA due to revised DCC operations in December-January), and increased entrainment at the export facilities (lesser effect in the final PA due to revised loss thresholds), which creates detrimental outmigration conditions and decreased survival by increasing the exposure of juvenile winter-run Chinook salmon to predation and poor water quality. These effects would lower the conservation value for winterrun Chinook salmon PBFs, including adequate river flows for successful spawning, incubation of eggs, fry development and emergence and downstream transport of juveniles (PBF 3) and water temperatures between 42.5 and 57.5°F (5.8 and 14.1°C) for successful spawning, egg incubation, and fry development (PBF 4).

Table 2.8.2-1. Summary of proposed action-related effects on winter-run Chinook salmon Critical Habitat organized by division component

Division	Action Comnent	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight o f Evidence	Probable Change in PBF Supporting the Life History Needs of the Species
Shasta	Summer Cold Water Management	Upper and middle	Water temperatures between 42.5—	Temperatures in excess of 57.5°F can	High	High: Supported by multiple	Decreased access to suitable water
	(	Sacramento	57.5°F (5.8-	lead to sublethal		scientific and	temperatures
		River	14.1°C) for	affects to adult		technical	
			successful	salmonids as well as		publications that	
			spawning, egg	abnormal development		include	
			incubation, and fry	or mortality of eggs		quantitative	
			development,	and larvae.		models specific to	
			Freshwater			the region and	
			Spawning Sites			species.	
Shasta	Spring Pulse Flow	Upper	Availability of	Spring pulse flows	Medium	Medium:	Increased or improved
		Sacramento	clean gravel for	could provide flows		Correlation of	quantity/quality of
		River	spawning substrate,	high enough to flush		flow and	spawning substrate
			Adequate river	fine sediments from		migration	
			flows for	spawning substrates.		supported by	
			successful	700		multiple scientific	
			spawning,			and technical	
			incubation of eggs,			publications but	
			fry development			magnitude of	
			and emergence,			benefit uncertain.	
			and downstream				
			transport of				
			juveniles,				
			Freshwater				
			Spawning Sites				

Shasta	Shasta	Shasta
Fall and Winter Refill and Redd Maintenance	Fall and Winter Refill and Redd Maintenance	Fall and Winter Refill and Redd Maintenance
Upper Sacramento River	Upper Sacramento River	Upper Middle Sacramento River
Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater Spawning Sites	Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater Spawning Sites	Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean, Freshwater Migration
Increased habitat carrying capacity (WUA) at lower flows providing increased feeding conditions, and decreased competition and predation.	Decreased month to month flows resulting in stranding caused by a loss of floodplain inundation and sidechannel habitat.	Decreased flows in September and November resulting in increased travel time and a decrease in survival because of increased predator interactions.
Low	Medium	Medium
High: Supported by multiple scientific and technical publications specific to the region and species. Quantitative results include WUA analysis.	Medium: Supported by select technical publications specific to the region and species. Quantitative results include month to month change.	Medium: Supported by select technical publications specific to the region and species. Quantitative results include month to month change.
Increased habitat carrying capacity necessary for successful spawning, incubation of eggs, fry development and emergence	Decreased flow limiting the downstream transport of juveniles	Decreased flow limiting the downstream transport of juveniles

month to month floodplain inundation
Quantitative results include WUA analysis and
decreased competition region and and predation.
and
providing increased publications
Increased habitat Low Medium:
substrate.
well as the quantity
flow to those areas as
includes increased effects.
for spawning which the extent of its
access to areas suitable implemented or
ect
Single Section 1
is
restoration project(s) available as to
information
implement side- very little
reclamation would action component)
management Concentant (Programmatic
I ow (I neartain)
yof
1
component would action component
area. This action how or where this
project(s) in the action available as to
gravel injection information
implement spawning very little
reclamation would action component)
As part of adaptive   Low (Uncertain)   Low:

reaches downstream of the Delta Interior, the DCC location, delaying migration or reducing survival of migrating fish in routes with more adverse
42.
()
the mainstem   downstream flow migratory corridor. 2)   characterisites for
reduces the value of negatively impacting
val of
1) Access to the Medium - Open gates
relative survival of adult salmonids entrained in water diversions (e.g. Yolo and Sutter Bypasses).
Minimization measure intended to increase
related to capture and
component. Increased stress and mortality
Framework Low (Uncertain) programmatic action
screening guidance.
operation is assumed to comply with NMFS
component.  Construction activities  are not described but
programmatic action

Delta	
Smelt Habitat (X2)	
and vicinity	
Winter-run PBFs: access to spawning areas, freshwater rearing sites, water temperatures, and freshwater migratory corridors.	
The action may result in changes to low salinity location, flow volume, and water temperatures. A small change in low salinity zone (X2) location would likely result in minimal effects to winter-run critical habitats. Water temperatures may be altered and have an effect on prey abundance, water quality, and migration corridor. Short-term changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG are not expected to significantly change habitat availability or suitability for rearing of listed anadromous fish.	
Low	time). Adults that stray into the Mokelumne River system due to open gates and then encountering closed gates will be delayed in their upstream migration.
Low	
Low	Lesser effect in final PA due to revised DCC operations in December-January.

Delta	Delta	Delta
Water Transfer	2.5.6.8.1.1.4 North Delta Food Subsidies / Colusa Basin Drain and Suisun Marsh Roaring River Distribution System Food Subsidy Studies	2.5.6.8.1.1.3 Sacramento Deep Water Ship Channel Food Study
Freshwater Rearing Habitat for Juveniles: Lower Sacramento River and Delta	North Delta	SDWSC downstream to Sacramento River confluence
Adequate river flows for successful downstream transport of juveniles;	Winter-run PBFs: freshwater migratory corridors, water quality, foraging habitat, rearing habitat.	Winter-run PBFs: foraging habitat, freshwater migratory corridors free of obstructions, and rearing habitat.
1) Improved flow conditions may improve water temperature conditions in the mainstem Sacramento River. 2) Improved flow conditions may improve dissolved oxygen conditions through improved mixing of water column and water	Water quality would be temporarily affected by the Colusa Basin drainage into the N Delta which would temporarily expose fish to agricultural drainage water potentially containing contaminants (pesticides, nutrients) during 2 months of the year. Exposure would be limited and temporary and would not likely affect survival.	Reconnecting the SDWSC to the Sacramento River will allow flow through the ship channel which will improve conditions (water temp, flow), but will impact habitat downstream by mobilizing contaminants and other water quality parameters.
Low- improved flows and water quality elements will affect a small proportion of winter-run emigrating downstream in the fall during the transfer window	Low	Low
Medium-multiple peer reviewed papers confirm benefits to water quality with increased flows. Effects to primary and secondary productivity from increased flows in Sacramento River less certain.	Low	Low
Increased flows due to water transfers from upstream reservoir releases will improve water temperatures and water quality conditions in the lower Sacramento River and upper Delta waterways. Effect will be temporary and related to the volume	Low	Low

Delta	Delta
2.5.6.8.1.1.4 Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Water Transfer
Suisun Marsh	Sacramento River and northern Delta
Winter-run PBFs: freshwater migratory corridors, water quantity, rearing habitat, access, and migratory corridors free of obstructions.	Freshwater migratory corridors
Fish passage will be affected by the operation of the SMSCG. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 70-80 days of annual operation. However, these changes in water flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Short-term changes in tidal flow are not expected to significantly change habitat availability or suitability	surface - air interface. 3) Improved water quality in fall may improve primary and secondary productivity benefitting forage base. Enhanced flows from water transfers can benefit juvenile winter-run in fall (October and November) migrating downstream by decreasing travel times, increasing the length of riverine reaches, and muting downstream tidal effects.
Low	Low- improved flows and water quality elements will affect a small proportion of winter-run emigrating downstream in the fall during the transfer window
Low	High, several recent papers using acoustic tag technology have shown the benefits of increased flows in enhancing migration survival
Low	and frequency of transfers.  Improved quality of freshwater migratory habitat during water transfers

### 2.8.2.3 Impact to the Critical Habitat of the Species at the Designation Level

Many of the PBFs that are essential for the conservation of the winter-run Chinook salmon ESU are currently degraded. As a result of implementing the PA, PBFs 1, 2, 5, 6, and 7 will likely remain the same, which will keep their conservation value low. The effects of the PA on water temperature would likely further degrade the value of PBFs 3 and 4.

To help evaluate the impact of the PA on critical habitat, it is useful to consider the habitat-based recovery criteria relating to migration and rearing corridors that are identified in the Recovery Plan (National Marine Fisheries Service 2014b). These criteria state that migration and rearing corridors must meet the life-history, water quality, and habitat requirements of the listed species, such that the corridor supports multiple viable populations. The rearing and migratory habitats of the Delta and Sacramento River currently do not meet these criteria for winter-run Chinook salmon, and the PA is expected to reduce the quality of habitat for egg incubation, and rearing and emigrating juveniles.

Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to result in a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of Sacramento River winter-run Chinook salmon (Table 2.8.2-2). Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.

Table 2.8.2-2 Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on Designated Critical Habitat. Dark shading indicates selection. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Step	Apply the Available Evidence to Determine if	True/False	Action
A	The proposed action is not likely to produce stressors that have direct or	True	End
	Available Evidence: The PA will produce multiple stressors that will adversely affect the environment including, but not limited to: warm water temperatures, increased water routing through the DCC, and increased exports at the south Delta export facilities.	False	Go to B
	Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect effects of	True	NLAA
В	the proposed action  Available Evidence: The PA will expose areas of critical habitat to multiple stressors, including but not limited to: (1) water temperatures warmer 57.5°F during spawning and egg incubation; (2) increased entrainment into the central and south Delta through the Delta Cross Channel gates; (3) increased entrainment at the south Delta export facilities.	False	Go to C
	The quantity or quality of any physical or biological features of critical habitat or capacity of that habitat to develop those features over time are	True	NLAA
С	not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action  Available Evidence: The PA will reduce stressors that will reduce the quality of PBFs including, but not limited to: (1) water temperatures warmer 57.5°F during spawning and egg incubation; (2) increased entrainment into the central and south Delta through the Delta Cross Channel gates; (3) increased entrainment at the south Delta export facilities.	False	Go to D
	Any reductions in the quantity or quality of one or more physical or biological features of critical habitat or capacity of that habitat to develop	True	NLAA
D	those features over time are not likely to reduce the value of critical habitat for the conservation of the species in the exposed area  Available Evidence: The PA will produce stressors that are likely to reduce the value of critical habitat for the conservation of the species in the exposed area, including but not limited to: water temperatures warmer 57.5°F during spawning and egg incubation, increased water routing through the DCC, and increased exports at the south Delta export facilities.	False	Go to E
Е		True	No D/AD MOD

Step	Apply the Available Evidence to Determine if	True/False	Action
	Any reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are not likely to appreciably diminish the overall value of critical habitat for the conservation of the species		D/AD MOD
	The PA will produce stressors that are likely to diminish the overall value of critical habitat for the conservation of the species, including but not limited to: water temperatures warmer 57.5°F during spawning and egg incubation, increased water routing through the DCC, and increased exports at the south Delta export facilities	False	

### 2.8.3 Central Valley Spring-run Chinook Salmon

### 2.8.3.1 Status of the Species and Environmental Baseline

This section provides a summary of the status of the CV spring-run Chinook salmon ESU and the environmental conditions that led to their status. A more complete description of CV spring-run Chinook salmon's status is presented in Section 2.2 and Appendix B, and the environmental baseline is fully characterized in Section 2.4.

CV spring-run Chinook salmon are currently listed as threatened, and are likely to become endangered in the foreseeable future throughout all or part of their range (National Marine Fisheries Service 2014b), but historically, CV spring-run Chinook salmon were one of the most abundant salmon runs on the west coast. The San Joaquin River supported an estimated average of 200,000 to 500,000 adults returning annually (California Department of Fish and Game 1990), but this population has since been extirpated. The Central Valley supported runs as large as 600,000 fish between the late 1880s and 1940s. Historically, there were 18 or 19 independent populations of CV spring-run Chinook salmon, along with a number of dependent populations, all within four distinct bio-geographic regions, or diversity groups. The four bio-geographic regions identified by the Central Valley Technical Recovery Team are the northwestern California diversity group, the basalt and porous lava diversity group, the northern Sierra diversity group, and the southern Sierra diversity group. Each of these diversity groups historically supported multiple CV spring-run Chinook salmon populations, which spread risk within and among the different Central Valley ecotypes. Having each diversity group represented was and remains critical to the species long-term persistence (Lindley et al. 2007).

The northwestern California diversity group contains one small population occurring in Clear Creek, and sporadic monitoring has revealed that CV spring-run Chinook salmon occupy Beegum Creek as well. In the basalt and porous lava diversity group, in addition to a potential returning population to the Sacramento River, downstream of Keswick Dam, a small population in Battle Creek currently occurs.

Only three independent populations currently exist (Mill, Deer, and Butte creeks, tributaries to the upper Sacramento River), and they represent only the northern Sierra Nevada diversity group (National Marine Fisheries Service 2014b). In the northern Sierra Nevada diversity group, CV spring-run Chinook salmon occur in the Feather and Yuba rivers where they are influenced by

hatchery-origin CV spring-run Chinook salmon produced at the Feather River Fish Hatchery, and smaller populations currently occur in Antelope and Big Chico creeks (California Department of Fish and Game 1998).

The historic populations of the San Joaquin River and its tributaries that make up the southern Sierra Diversity Group were extirpated by the construction and operation of large dams. However, observations over the last decade suggest that spring-running populations may occur in the Stanislaus and Tuolumne rivers (Franks 2014), and the San Joaquin River Restoration Program aimed at restoring San Joaquin River and reintroducing CV spring-run Chinook salmon is well underway.

A conservation stock of CV spring-run Chinook salmon was developed at the San Joaquin River Conservation and Research Facility at Friant Dam and individuals have been released annually since 2014 to the lower San Joaquin River (California Department of Fish and Wildlife 2014b). These reintroduced fish have been designated as a nonessential experimental population under ESA section 10(j) in the San Joaquin River from Friant Dam downstream to its confluence with the Merced River (78 FR 79622 2013). When these fish migrate to and from the ocean, or when they stray into other areas outside the San Joaquin River, they are considered part of the non-experimental CV spring-run Chinook salmon ESU.

When designating the San Joaquin River CV spring-run Chinook salmon experimental population, NMFS needed to determine whether the experimental population was essential to the continued existence of the species in the wild. The nonessential designation was based on the existence in the Sacramento River basin of four independent populations, one of which is supplemented by a hatchery, and several dependent or establishing populations, the extinction of which would not be affected should the experimental population be extirpated. The nonessential designation of the San Joaquin River experimental population means it is not essential to the continued existence of the listed CV spring-run Chinook salmon ESU. As such, NMFS does not include effects to the experimental population when determining whether or not the PA will reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution. Additionally, the San Joaquin Basin does not contain designated critical habitat.

Although there have been observations of spring-time running Chinook salmon returning to the San Joaquin tributaries in recent years, there is insufficient information to determine the specific origin of these fish, and whether or not they are straying into the basin or returning to natal streams. Genetic assessment or natal stream analyses of hard tissues could inform our understanding of the relationship of these fish to the ESU (National Marine Fisheries Service 2016a). Because it is uncertain whether or not the adult spring-running Chinook salmon that have been observed in the San Joaquin tributaries constitute a spawning population (as opposed to strays), and because the non-essential experimental population is excluded from the jeopardy conclusion, the entire southern Sierra Nevada diversity group, including the lower San Joaquin River, is excluded from our conclusion about whether or not the PA will reduce appreciably the likelihood of both the survival and recovery of CV spring-run Chinook salmon.

Given that the CV spring-run Chinook salmon ESU is composed of several populations, all of which are impacted by the PA to varying degrees, the ESU structure and population priorities (Table 2.8.3-1) identified in the Central Valley Chinook salmon and Steelhead Recovery Plan provide a helpful context for assessing how the PA is expected to affect species viability

(National Marine Fisheries Service 2014b). For example, the population priorities identified in the Recovery Plan indicate the relative importance of each population to the ESU's extinction risk – a higher priority population has a greater impact on the CV spring-run Chinook salmon ESU's survival and recovery than a lower priority population.

As described in the Recovery Plan, watersheds in the four diversity groups were prioritized into three categories. Core 1 watersheds possess the known ability or potential to support a viable population. For a population to be considered viable, it must meet the criteria for low extinction risk for Central Valley salmonids (Lindley et al. 2007). Core 2 populations meet, or have the potential to meet, the biological recovery standard for moderate risk of extinction. Core 3 watersheds have populations that are present on an intermittent basis and require straying from other nearby populations for their existence. These populations likely do not have the potential to meet the abundance criteria for moderate risk of extinction. Although Core 3 watersheds are the lowest priority, they remain important because so many historic populations have already been extirpated, and, like Core 2 watersheds, they support populations that provide increased life history diversity to the ESU/DPS and are likely to buffer against local catastrophic occurrences that could affect other nearby populations.

The diversity group and population priority lens helps put the PA's impacts on the CV spring-run Chinook salmon ESU into context. The importance of the Clear Creek population to the ESU is illuminated given that it is identified as a "Core 1" population and is likely the only population in the Northwestern California diversity group with the potential to meet the recovery criteria calling for one viable population in the diversity group. The combined effect of multiple stressors on Clear Creek CV spring-run Chinook salmon with implementation of the PA are expected to reduce the population's viability. Relative to the Clear Creek population, the PA's potential impact on CV spring-run Chinook salmon occurring in the Sacramento River carries slightly less weight. However, given that most historic independent CV spring-run Chinook salmon populations have already been extirpated, NMFS considers that an expected appreciable reduction in any population's viability due to implementation of the PA would also appreciably reduce the likelihood of survival and recovery of the population's diversity group and the ESU. All of the Sacramento River Basin populations are affected by the PA as they migrate through the Sacramento River and Delta.

Table 2.8.3-1. Central Valley Spring-run Chinook Salmon Diversity Groups, and Watershed Prioritization (modified from NMFS 2014b). Only watersheds currently supporting spring-run Chinook salmon are shown.

Diversity Group (number of viable populations needed to meet ESU level recovery criteria)	River or Creek	Priority
Basalt and Porous Lava (2)	Battle Creek	Core 1
	Sacramento River (downstream from Keswick)	Core 2
Northwestern California (1)	Thomes Creek	Core 3
	Cottonwood/Beegum Creek	Core 2
	Clear Creek	Core 1
Northern Sierra Nevada (4)	Feather River (downstream from Oroville)	Core 2
	Yuba River downstream from Englebright)	Core 2
	Butte Creek	Core 1
	Big Chico	Core 2
	Deer Creek	Core 1
	Mill Creek	Core 1
	Antelope Creek	Core 2
Southern Sierra Nevada (2)	San Joaquin River (downstream from Friant)	Primary for reintroduction

The SWFSC concluded in their most recent viability report that the status of CV spring-run Chinook salmon (through 2014) has probably improved since the 2010/2011 status review and that the ESU's extinction risk may have decreased, however the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years as the full effects of the recent drought are realized (Williams et al. 2016). Those drought effects indeed took a toll as the abundance of multiple populations have dropped to near all-time lows since 2014 (Figure 2.4.4-1).

Many factors have inhibited the ability of CV spring-run Chinook salmon to respond and adapt to drought and other environmental pressures. Those factors include, but are not limited to loss of historical spawning and rearing habitat, degradation of the remaining accessible habitat, water management, and threats to genetic integrity from hatchery influences.

Reclamation established a "without-action" scenario as part of the BA's Environmental Baseline to isolate and define potential effects of the proposed action apart from effects of non-proposed action. NMFS considers the without-action scenario to represent effects related to the existence of CVP and SWP facilities. The without-action scenario provides context for how these facilities

have shaped the habitat conditions for species and critical habitat in the action area. Under Reclamation's "without action" scenario, there would be both positive and negative effects on the status of CV spring-run Chinook salmon. Higher flows in winter and spring could have both positive and negative effects on salmonids. Benefits of higher flows include lower water temperatures, increased dissolved oxygen, increased habitat complexity, more rearing habitat, more refuge habitat, increased availability of prey, less predation risk, less entrainment risk, lower potential for pathogens and disease, lower concentrations of toxic contaminants, and emigration cues. Reduced flows during dry fall months would have negative impacts on spawning adults, eggs, and alevin, and on rearing juvenile salmonids, resulting in increased temperature-dependent mortality of eggs, reduced juvenile growth rate and higher mortality of the juveniles, and a reduced population abundance.

However, as discussed previously, the Environmental Baseline also includes the effects of past and current operations of the CVP and SWP, and the additional effects of habitat restoration, predation from invasives, water quality, and other effects on species from Federal, State, and private actions to inform the current condition of CV spring-run Chinook salmon. As discussed above, the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years.

### 2.8.3.2 Summary of Proposed Action Effects

Proposed action-related effects to CV spring-run Chinook salmon are summarized in

Table 2.8.3-2. Detailed descriptions regarding the exposure, response, and risk of spring-run Chinook salmon to these stressors and conservation measures are presented in Section 2.5.

Reclamation has committed to implement or continue to implement conservation measures (restoration actions or programs), as part of the PA in Table 4-6 of the ROC on LTO BA, which are expected to partially address adverse effects of the ongoing operation of the CVP/SWP. For conservation measures that previously underwent separate ESA section 7 consultations, those beneficial effects are described and factored into the Environmental Baseline section of this Opinion. For conservation measures without a completed ESA section 7 consultation, the effects are analyzed or described in the Effects section of this Opinion at either the framework-level or at a more action specific-level, depending on the level of detail available in the ROC on LTO BA. Both framework-level and action specific-level conservation measures included in the PA are factored into the jeopardy analysis.

### As shown in

Table 2.8.3-2, PA-related stressors are expected to reduce the fitness of individuals during the adult, egg, fry, and juvenile life stages for CV spring-run Chinook salmon originating from the Sacramento River and Clear Creek; and reduce the fitness of individuals from all CV spring-run Chinook salmon populations as they pass through the Delta. The cumulative effect of these stressors throughout the life cycle likely has important consequences for the viability of the population, as Naiman and Turner (2000) demonstrated that it is possible to drive a Pacific salmon population to extinction (or to increase population size), by only slight changes in survivorship at each life history stage (Figure 2.1.3-5).

Table 2.8.3-2. Summary of proposed action-related effects on spring-run Chinook salmon for the Shasta (Sacramento River), Trinity (Clear Creek), and Delta divisions. Within each division, components are listed top to bottom in the following order: high magnitude stressors, high magnitude benefits, medium magnitude stressors, medium magnitude benefits, low magnitude stressors, low magnitude benefits, uncertain stressors/benefits.

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Upper Sacrament o/ Shasta Division	Upper Sacrament o/ Shasta Division	Upper Sacrament o/ Shasta Division	Division
Tier 3 (Shasta Cold Water Pool Mgmt.)	Tier 2 (Shasta Cold Water Pool Mgmt.)	Tier 1 (Shasta Cold Water Pool Mgmt.)	Action Component
Water Temperature	Water Temperature	Water Temperature	Stressor/Fact
Eggs/Fry (Keswick Dam - BSF gauge)	Eggs/Fry (Keswick Dam - BSF gauge)	Eggs/Fry (Keswick Dam - BSF gauge)	Life Stage (Location)
August - December (August - October)	August - December (August - October)	August - December (August - October)	Life Stage Timing (Work Window Intersecti
Temperatures higher than 53.5°F would cause a decrease in egg survival.	Temperatures higher than 53.5°F would cause a decrease in egg survival.	Temperatures higher than 53.5°F would cause a decrease in egg survival.	Individual Response and Rationale of Effect
Lethal	Lethal	Lethal	Severity of Stressor/ Level of Benefit
Large (97% of days >53.5°F)	Large (80% of days >53.5°F)	Large (76% of days >53.5°F)	Proportion of Population Exposed
Low (7% of years)	Low (17% of years)	Medium (68% of years)	Frequenc y of Exposure
High	High	High	Magnitu de of Effect
High: Supporte d by multiple scientific and technical publicati ons	High: Supporte d by multiple scientific and technical publicati ons	High: Supporte d by multiple scientific and technical publicati ons	Weight of Evidenc
Reduced survival probability	Reduced survival probability	Reduced survival probability	Probable Change in Fitness

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Division  Division  Upper Sacrament o/Shasta Division	Upper Sacrament	Division
Mgmt.) Mgmt.)  Delta Smelt Summer-Fall Habitat	Tier 4 (Shasta Cold	Action Component
Water Temperature	Water Temperature	Stressor/Fact
gauge)  Eggs/Fry (Keswick Dam - BSF gauge)	Eggs/Fry (Keswick	Life Stage (Location)
October)  August - December (August - October)	August - December	Timing (Work Window Intersecti on)
cause a decrease in egg survival.  Framework programmatic action component. Action subcomponents that utilize reservoir releases to achieve additional Delta outflow and increase habitat quantity would reduce cold water pool that would otherwise be available for summer temperature management.	Temperatures higher than	Individual Response and Rationale of Effect
Lethal	Lethal	Severity of Stressor/ Level of Benefit
vays >53.5°F) Large	Large (99.6% of	Proportion of Population Exposed
Low	Low (7% of years)	Frequenc y of Exposure
High	High	Magnitu de of Effect
multiple scientific and technical publicati ons High: Supporte d by multiple scientific and technical publicati ons that include quantitati ve models specific to the region and species.	High: Supporte	Weight of Evidenc e
Reduced survival probability	Reduced survival	Probable Change in Fitness

Sacrament o/ Shasta Division	Division
Fall and Winter Refill and Redd Maintenance	Action Component
Spawning Habitat Availability, Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function	Stressor/Fact
Redds (Upper Sacramento River)	Life Stage (Location)
August - December (October, November )	Life Stage Timing (Work Window Intersecti on)
Decreased month-to-month flows resulting in possible redd dewatering and decreased floodplain inundation and side-channel habitat.	Individual Response and Rationale of Effect
Lethal	Severity of Stressor/ Level of Benefit
Large	Proportion of Population Exposed
of years)	Frequenc y of Exposure
High	Magnitu de of Effect
Medium: Supporte d by a limited number of scientific and technical publicati ons specific to the region and species. Quantitat ive results month- to-month channel inundatio n (U.S. Fish and Wildlife Service	Weight of Evidenc
Reduced survival probability	Probable Change in Fitness

on the state of th	Division C
Minimum flows	Action Component Winter
Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function	Stressor/Fact or Flow
(Upper mid- Sacramento River)	Life Stage (Location) Juveniles
- April (Decembe r - February)	Life Stage Timing (Work Window Intersecti on) November
habitat carrying capacity (WUA) at lower flows providing decreased feeding conditions, and increased competition and predation. Decreased month-to-month flows resulting in decreased floodplain inundation and side-channel habitat.	Individual Response and Rationale of Effect Decreased
, Lethal	Severity of Stressor/ Level of Benefit
95% of population)	Proportion of Population Exposed Large (90-
(Yearly)	Frequenc y of Exposure
	Magnitu de of Effect
Supporte d by multiple scientific and technical publicati ons specific to the region and species. Quantitat ive results include WUA analysis and monthfoodplai n inundatio	Weight of Evidenc e
growth rate, Reduced survival probability	Probable Change in Fitness

Upper Sacrament o/Shasta Division	Division Upper Sacrament o/ Shasta Division
Temperature  Modeling  Platform	Action Component Spring Pulse It Flow
Water Temperature under Tier management	Stressor/Fact or Flow Conditions, Loss of Natural River Morphology and Function Passage Impediments/ Barriers
Eggs/Fry (Keswick Dam - BSF gauge)	Life Stage (Location) Juveniles, Migrating Adults (Middle, Lower Sacramento River)
August - December (August - October)	Timing (Work Window Intersecti on) January - May (March - May), February - August (March - May 15)
Improved modeling should help reduce the uncertainty related to temperature forecasting which could minimize temperature dependent mortality for winter-run	Individual Response and Rationale of Effect Elevated flows reduce migration times for juveniles, which will in turn reduce predation opportunities. For adults increased flows facilitate upstream migration. High flows are also correlated with lower temperatures that benefit females migrating upriver by ensuring that eggs are not damaged before spawning.
Benefici al: Low	Severity of Stressor/ Level of Benefiti Benefici al: High
Large	Proportion of Population Exposed Large (75% of Juveniles), Large (Adults)
Medium	Frequenc y of Exposure Medium (<75% of years)
Medium	Magnitu de of Effect High, Medium
High: Supporte d by multiple scientific and technical publicati ons that include quantitati ve models	Weight  of Evidenc  e  High: Multiple scientific and technical publicati ons indicate an associati on Sacrame nto River or Delta flow and juvenile salmon survival (Michel et al. 2015, Perry et al. 2018).
Increased survival probability	Probable Change in Fitness Improved (juvenile) survival probability, Improved reproductive success

Upper Sacrament o/Shasta Division	Division
Drought and Dry Year Actions	Action Component
Water Temperature	Stressor/Fact or
Eggs/Fry (Keswick Dam - BSF gauge)	Life Stage (Location)
August - December (August - October)	Life Stage Timing (Work Window Intersecti on)
Drought and Dry Year Actions have been identified for winter-run Chinook salmon as a way to mitigate for temperatures higher than 53.5°F which result in reduced survival. These actions are expected to benefit other species, ESUs and DPSs in the Sacramento River as well but to a lesser degree.	Individual Response and Rationale of Effect Chinook salmon and to a lesser extent the other ESUs or DPSs spawning in the Sacramento River.
Benefici al: Low	Severity of Stressor/ Level of Benefit
Large	Proportion of Population Exposed
Low	Frequenc y of Exposure
Medium	Magnitu de of Effect
High: Supporte d by multiple scientific and technical publicati ons that include quantitati ve models specific to the region and species.	Weight of Evidenc e specific to the region and species.
Increased survival probability	Probable Change in Fitness

Upper Sacrament o/ Shasta Division	Upper Sacrament o/Shasta Division	Division
Tier 1 (Shasta Cold a Water Pool Mgmt.)	Drafting of It Temperature Management Plan Using Conservative Forecasts	
Water Temperature	Water Temperature	Stressor/Fact
Holding & Spawning Adults (Keswick Dam - BSF gauge)	Eggs/Fry (Keswick Dam - BSF gauge)	Life Stage
March - October (May 15 - October)	August - December (August - October)	Life Stage Timing (Work Window Intersecti
Temperatures in excess of 61°F expected to lead to stress, disease, and bioenergetic depletion.	Using conservative forecasts to inform the development of the Temperature Management Plan is expected to reduce the frequency of there being temperatures higher than 53.5°F during the winter-run Chinook salmon spawning and incubation period. It is expected to provide an indirect benefit to the other species, ESUs, and DPSs that spawn in the Sacramento River as well.	Individual Response and Rationale of
Sublethal	Benefici al: Low	Severity of Stressor/ Level of
Small (1% of days >61°F)	Large	Proportion of Population
Medium (45% - 68% of years)	High	Frequenc y of
Low	Medium	Magnitu de of
Medium: Supporte d by multiple scientific and technical publicati ons, however	High: Supporte d by multiple scientific and technical publicati ons that include quantitati ve models specific to the region and species.	Weight of Evidenc
Reduced reproductive success	Increased survival probability	Probable Change in

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Upper Sacrament o/ Shasta Division	Upper Sacrament o/ Shasta Division	Division
Tier 3 (Shasta Cold Water Pool Mgmt.)	Tier 2 (Shasta Cold Water Pool Mgmt.)	Action Component
Water Temperature	Water Temperature	Stressor/Fact or
Holding & Spawning Adults (Keswick Dam - BSF gauge)	Holding & Spawning Adults (Keswick Dam - BSF gauge)	Life Stage (Location)
March - October (May 15 - October)	March - October (May 15 - October)	Life Stage Timing (Work Window Intersecti on)
Temperatures in excess of 61°F expected to lead to stress, disease, and bioenergetic depletion.	Temperatures in excess of 61°F expected to lead to stress, disease, and bioenergetic depletion.	Individual Response and Rationale of Effect
Sublethal	Sublethal	Severity of Stressor/ Level of Benefit
Medium (13% of days >61°F)	Small (1% of days >61°F)	Proportion of Population Exposed
Low (7% - 15% of years)	Low to Medium (17% - 35% of years)	Frequenc y of Exposure
Low	Low	Magnitu de of Effect
Medium: Supporte d by multiple scientific and technical publicati ons, however not specific to the region	Medium: Supporte d by multiple scientific and technical publicati ons, however not specific to the region and species.	Weight of Evidenc e not specific to the region and species.
Reduced reproductive success	Reduced reproductive success	Probable Change in Fitness

Upper Sacram o/ Shas Divisio	Upper Sacran o/ Shas Divisio	Di
Upper Sacrament o/ Shasta Division	Upper Sacrament o/ Shasta Division	Division
Rice Decomp smoothing (fall ops.)	Tier 4 (Shasta Cold Water Pool Mgmt.)	Action Component
Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function	Water Temperature	Stressor/Fact
Redds (Upper Sacramento River)	Holding & Spawning Adults (Keswick Dam - BSF gauge)	Life Stage (Location)
August - December (October, November )	March - October (May 15 - October)	Life Stage Timing (Work Window Intersecti on)
Framework level action component. Proposed coordination may provide more reliable fall flows affecting action component Fall and Winter Refill and Redd Maintenance (2.5.2.3.4.1)	Temperatures in excess of 61°F expected to lead to stress, disease, and bioenergetic depletion.	Individual Response and Rationale of Effect
Benefici al: Low	Sublethal	Severity of Stressor/ Level of Benefit
Medium (33% - 42% of redds potentially dewatered); Low proportion benefit from storage increase	Medium (36% of days >61°F)	Proportion of Population Exposed
Low	Low (5% - 7% of years)	Frequenc y of Exposure
Low (Uncerta in)	Low	Magnitu de of Effect
Low: uncertain ty of action compone nt impleme ntation or its effects	Medium: Supporte d by multiple scientific and technical publicati ons, however not specific to the region and species.	Weight of Evidenc e and species.
Increased reproductive success	Reduced reproductive success	Probable Change in Fitness

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Increased survival at diversion (decreased entrainment)	Low: (Program matic action compone nt) very little informati on available as to how this action compone nt would be impleme nted	Low	(Uncertain	Low	Benefici al: Low	Framework level action component Construction activities are not described but assumed construction effects related to installation of fish screens include: changes in flow, stranding (installation of coffer dams), and handling.	March - September (June - September ) November - April (no overlap with proposed constructi on timing),	Adults, Juveniles (Middle Sacramento River)	Construction or installation of fish screens on water diversions. Passage Impediments/ Barriers, Flow Conditions, Loss of Riparian Habitat and Instream Cover	Small Screen Program (Spawning/r earing habitat restoration)	Upper Sacrament o/ Shasta Division
Decreased survival probability	Low: (uncertai n) very little informati on available as to how this action compone nt would be impleme nted (construc tion).		Uncertain (dependin g on Constructi on timing/ext ent)	Small	Sublethal	Framework level action component, construction activities are not described. NMFS assumes that construction would occur during an appropriate in- water work window and include BMPs and minimization measures to limit potential effects to species	March - September (June - September	Adults, (Middle Sacramento River)	Construction or installation of fish screens on water diversions. Passage Impediments/ Barriers, Flow Conditions, Loss of Riparian Habitat and Instream Cover	Wilkins Slough intakes (Cold water pool mgmt.)	Upper Sacrament o/ Shasta Division
Probable Change in	Weight of Evidenc	Magnitu de of Effect	Frequenc y of	Proportion of Population	Severity of Stressor/ Level of Renefit	Individual Response and Rationale of	Life Stage Timing (Work Window Intersecti	Life Stage	Stressor/Fact	Action	Division

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Upper Sacrament o/ Shasta Division	Upper Sacrament o/ Shasta Division	Division
Side- Channel habitat (Spawning/r earing habitat restoration)	Adult rescue (tier 4 intervention)	Action Component
Riparian vegetation, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Passage Impediments/ Barriers, Entrainment/I mpingement at water diversions	Stressor/Fact or
Adults, Juveniles (Middle Sacramento River)	Adults (Middle Sacramento River)	Life Stage (Location)
March - September (June - September ) November - April (no overlap with proposed constructi	March - September (Uncertain )	Life Stage Timing (Work Window Intersecti on)
Increased habitat quality and quantity. Framework level action component.	Uncertain. Programmatic action component. Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of adult salmonids entrained in water diversions (e.g. Yolo and Sutter Bypasses).	Individual Response and Rationale of Effect
Benefici al: Medium	Benefici al: Low	Severity of Stressor/ Level of Benefit
Low/Mediu m	Uncertain	Proportion of Population Exposed
High (Permanen t)	Uncertain, Low (tier 4 years = 5 - 7% of all years)	Frequenc y of Exposure
Low	Low (Uncerta in)	Magnitu de of Effect
Medium: (previous Program matic Opinion evaluate d)	Low: (Program matic action compone nt) very little informati on available as to how this action compone nt would be impleme nted or as to its effects.	Weight of Evidenc e (construction).
Continued Increased growth rate, increased production/s pawning success	Increased reproductive success, Increased survival probability	Probable Change in Fitness

Upper Sacrament o/ Shasta Division	Upper Sacrament o/ Shasta Division	Division
Wilkins Slough intakes (Cold water pool mgmt.)	Spawning Gravel Injection (Spawning/r earing habitat restoration)	Action Component
Operation of new or repaired fish screens on water diversions. Entrainment/I mpingement at water diversions	Spawning Habitat Availability, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Stressor/Fact or
Juveniles (Middle Sacramento River)	Adults, Juveniles (Middle Sacramento River)	Life Stage (Location)
November - April (no overlap with proposed constructi on timing),	August - October November - April	Life Stage Timing (Work Window Intersecti on) on
Framework level action component, operation is assumed to comply with NMFS and CDFW fish screening guidance.	Increased habitat quality and quantity. Framework level action component.	Individual Response and Rationale of Effect
Benefici al: Low	Benefici al: Low	Severity of Stressor/ Level of Benefit
Large	Uncertain	Proportion of Population Exposed
High (Permanen t)	High (Permanen t)	Frequenc y of Exposure
Uncertai n, High	Low	Magnitu de of Effect
Low: (uncertai n) very little informati on available as to how this action compone nt would be impleme inted or its effects when operated.	Medium: (Previou s program matic Opinion evaluate d)	Weight of Evidenc
Increased survival probability,	Increased growth rate, Increased lifetime reproductive success	Probable Change in Fitness

Upper Ju- Sacrament Tr. o/ Shasta Ha Division int	Division Cu Upper Sn Sacrament Sc o/ Shasta Pr Division ear ha
Juvenile Trap and Haul (tier 4 intervention)	Action Component Small Screen Program (Spawning/r earing habitat restoration)
Monitoring, Maintenance, Research Studies, etc. (minimization for Water Temperatures)	Stressor/Fact or Operation of new or repaired fish screens on water diversions. Entrainment/I mpingement at water diversions
Juveniles (Upper Sacramento River)	Life Stage (Location) Juveniles (Middle Sacramento River)
November - April (Uncertain ),	Timing (Work Window Intersecti on) November - April (Uncertain ),
Framework-level Programmatic action component. Increased survival –small proportion stress and mortality related to capture and handling. Minimization measure	Individual Response and Rationale of Effect Framework level action component. Programmatic action component. Construction activities are not described but operation is assumed to comply with NMFS and CDFW fish screening guidance.
Benefici al: Uncertai n	Severity of Stressor/ Level of Benefit Benefici al: High
Uncertain	Proportion of Population Exposed Uncertain
Low (7% of years)	Frequenc y of Exposure High (Permanen t)
Uncertai n	Magnitu de of Effect Uncertai n, High
Low: (Program matic action compone nt) very little informati on available as to how this action	Weight of Evidenc e Low: (Program matic action compone nt) very little informati on available as to how this action compone nt would be impleme nted (construc tion) or its effects when operated.
Increased survival	Probable Change in Fitness Increased survival probability (NMFS/CD FW fish screening criteria 5% loss),

Upper Sacrament o/ Shasta Division		Division
Operation of t a Shasta Dam Raise		Action Component
NA		Stressor/Fact
AA		Life Stage (Location)
NA		Life Stage Timing (Work Window Intersecti on)
None. Reclamation has committed to no change in operations with the inclusion of a Shasta Dam raise such that there will be no change in the frequency of meeting management criteria nor will there be any change in the timing and volume of releases.	intended to increase relative survival of Juvenile winterrun during Tier 4 water temperature operations. Depending on timing and location of trap and haul operations, juvenile springrun could be collected and returned to the river or relocated.	Individual Response and Rationale of Effect
AN		Severity of Stressor/ Level of Benefit
AN		Proportion of Population Exposed
AN		Frequenc y of Exposure
NA		Magnitu de of Effect
NA	nt would be impleme nted or as to its effects.	Weight of Evidenc
None		Probable Change in Fitness

Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Upper Sacrament o/ Shasta Division	Division
Spring attraction pulse flows	Spring attraction pulse flows	Water temperature management : Summer	Water temperature management : Fall	Shasta TCD improvemen ts (Cold water pool mgmt.)	Action Component
Flow Conditions; Loss of Natural River Morphology and Function; Passage	Flow Conditions	Water Temperature	Water Temperature, Spawning Habitat Availability.	Water Temperature	Stressor/Fact
Adults migrating/h olding:creek -wide	Juveniles: creek-wide	Adults holding downstream of compliance point.	Eggs/ alevins upstream and downstream of compliance point.	all	Life Stage (Location)
May-Jun	May-Jun	Jun-mid Sept	Sept-Oct	Warmer months	Life Stage Timing (Work Window Intersecti on)
Increased flows create migration cues by increasing turbidity, decreasing water temperatures, and improving	Flow decreases cause isolation and stranding. Ramping rates will reduce the magnitude.	Adults are exposed to >60°F, which may cause stress, disease, reduced fecundity, and prespawn mortality.	Redds are exposed to water temperatures >56°F, resulting in temperature dependent mortality.	Framework level action component. Unknown changes/modific ations to existing	Individual Response and Rationale of Effect
Benefici al: Low- Medium	Sublethal - Lethal	Sublethal	Lethal and Sublethal	NA	Severity of Stressor/ Level of Benefit
High	Small	Medium	Medium	AN	Proportion of Population Exposed
High (annual)	High (annual)	Medium	Medium	NA	Frequenc y of Exposure
Low - Medium, given the limited success of this action in the past	Medium	Medium	High- Medium	NA	Magnitu de of Effect
Medium	Medium	Medium: supporte d by water temperat ure and monitori ng data	High: supporte d by water temperat ure and monitori ng data.	Low: (uncertai nty regardin g effective ness) t	Weight of Evidenc
Increased survival. Increased reproductive success	Reduced survival.	Reduced reproductive success.	Reduced survival and reduced reproductive success.	Increased survival	Probable Change in Fitness

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Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)		Division
Water temperature management : Summer	Water temperature management : Summer	Minimum instream base flows		Action Component
Water Temperature	Water Temperature	Flow Conditions; Passage Impediments	Impediments/ Barriers	Stressor/Fact
Adults migrating creek-wide	Juveniles: creek-wide	Adults migrating creek-wide		Life Stage (Location)
Jun-Aug	Jun-Sept	Jun-Sept		Timing (Work Window Intersecti on)
Warm water temperatures >65°F may block or inhibit	Temperatures may be above optimal growth and survival >65°F. Increased stress, risk of predation and disease.	Low flow barriers at riffles and cascades may inhibit access to holding locations.	passage of physical barriers to the most upstream reaches for holding. Implementation of this action in the past has helped attract spring-run into Clear Creek, but has had limited success attracting them to upstream holding habitats.	Individual Response and Rationale of Effect
Minor	Minor	Minor		Severity of Stressor/ Level of Benefit
Small	Small	Medium		Proportion of Population Exposed
High	High	High		Frequenc y of Exposure
Low	Low	Medium	(see Respons e column)	Magnitu de of Effect
Medium	Medium	Low		Weight of Evidenc e
Reduced survival and reproductive success	Reduced growth and survival.	Reduced survival and reproductive success		Probable Change in Fitness

Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Division	
Spring attraction pulse flows	Channel maintenance pulse flows	Minimum instream base flows.	Action Component	
Flow Conditions; Loss of Natural River Morphology and Function; Passage Impediments/ Barriers	Flow Conditions	Flow conditions	Stressor/Fact or	
Juveniles/ smolts: creek-wide	Juveniles/ smolts: creek-wide	Eggs/ alevins: upstream of segregation weir	Life Stage (Location)	
May-Jun	Jan-Apr	Nov-Jan	Intersecti on)	Life Stage Timing (Work Window
Increased flows create migration cues and improve downstream passage by decreasing water temperatures, increasing turbidity.	Flow decreases cause isolation and stranding. Ramping rates will reduce the magnitude.	Base flow reductions in Critical water year types, and/or after the fall water temperature management period will dewater redds. Eggs and alevins will be exposed to effects of dewatering and reduced hyporheic flow.	Rationale of Effect upstream migration	Individual Response and
Benefici al: Low	Sublethal	Sublethal	Level of Benefit	Severity of Stressor/
Low	Medium	Medium	Population Exposed	Proportion of
High (annual)	Medium (30-60% of years)	Low	y of Exposure	Frequenc
Low	Low	Low	de of Effect	Magnitu
Medium	Medium	Medium	Evidenc e	Weight
Increased growth. Improved survival. Increased life history diversity.	Reduced survival.	Reduced survival.	Change in Fitness	Probable

Trinity (Clear Creek)	Trinity (Clear Creek)	Division
Channel maintenance pulse flows	Channel maintenance pulse flows	Action Component
Flow Conditions, Loss of Natural River Morphology and Function, Passage Impediments/ Barriers	Flow Conditions, Loss of Natural River Morphology and Function, Passage Impediments/ Barriers	Stressor/Fact or
Adults migrating: creek-wide	Juveniles/ smolts: creek-wide	Life Stage (Location)
Mar-Apr	Jan-Apr	Life Stage Timing (Work Window Intersecti on)
Increased flows create migration cues by increasing turbidity, decreasing water temperatures, and improving passage of physical barriers to the most upstream reaches for holding.	Increased flows create migration cues and improve downstream passage: decreasing water temperatures, increasing turbidity and reducing predation risk. Provide temporary access to additional rearing habitat.	Individual Response and Rationale of Effect Provide temporary access to additional rearing habitat.
Benefici al: Low	Benefici al: Low	Severity of Stressor/ Level of Benefit
Low	Medium	Proportion of Population Exposed
Medium (30-60% of years)	Medium (30-60% of years)	Frequenc y of Exposure
Low	Low	Magnitu de of Effect
Medium	Medium	Weight of Evidenc e
Increased survival. Increased reproductive success	Increased growth. Improved survival. Increased life history diversity.	Probable Change in Fitness

Delta	Division
DCC Gate operations -	Action Component
Altered Hydrodynami cs downstream of DCC location	Stressor/Fact
Juveniles - Sacramento River -Delta	Life Stage (Location)
Juvenile migration and rearing - Dec - May	Life Stage Timing (Work Window Intersecti on)
Increased mortality when gates are open due to changes in routing or transit time through interactions with changes in river flow and tidal influence downstream of DCC location and gate operations	Individual Response and Rationale of Effect
Lethal	Severity of Stressor/ Level of Benefit
Medium - opening of gates reduces the proportion of riverine reaches adjacent to the DCC location; closing of gates extends the riverine reaches farther downstrea m. All fish emigrating in Oct and Nov have the potential to see open gates, fish emigrating in a drought year may see up to 10 days in Dec and January with the gates in the open position, although	Proportion of Population Exposed
High	Frequenc y of Exposure
High	Magnitu de of Effect
High - There are a number of publicati ons regardin g the relative survival in various North Delta and Central Delta migrator y routes; conclusi ons supporte d by modellin g results.	Weight of Evidenc
reduced fitness and/or survival when gates are open; lesser effect in final PA due to revised DCC operations in December-January	Probable Change in Fitness

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Delta		Division
CVP Improvemen ts		Action Component
injections		Stressor/Fact
Juveniles - Sacramento River -Delta		Life Stage (Location)
Juvenile migration and rearing - Dec - May		Life Stage Timing (Work Window Intersecti on)
Removal of predators from secondary channel at the Tracy Fish Collection Facility		Individual Response and Rationale of Effect
Benefici al: High		Severity of Stressor/ Level of Benefit
Medium	the joint probability of occurrence is 1 in 10 years.	Proportion of Population Exposed
High		Frequenc y of Exposure
High		Magnitu de of Effect
Medium - several studies have looked at predation impacts in the salvage process, long term effective ness of this method is not certain		Weight of Evidenc
Increased survival		Probable Change in Fitness

Delta	Division Delta
CVP/SWP South Delta Exports	Action Component DCC Gate operations -
Altered hydrodynamic s in south Delta/ routing	Stressor/Fact or Routing
Juveniles - Sacramento River -Delta	Life Stage (Location) Juveniles - Sacramento River - Delta
Juvenile migration and rearing - Dec - May	Timing (Work Window Intersecti on) Juvenile migration and rearing - Dec - May
Mortality or decreases in condition due to migratory delays in response to altered hydrodynamics in channels of the south Delta. Loss of appropriate migratory cues. Delays increase	Individual Response and Rationale of Effect increased mortality due to routing into the delta interior with lower survival rates
Sublethal to Lethal	Severity of Stressor/ Level of Benefit Sublethal - Lethal
Medium -	Proportion of Population Exposed Medium - gates open from Oct 1 through Nov 30, typically closed Dec 1 through Jan 31. Closed Feb 1 through Jan 39. Estimated 5% of juvenile SR population emigrates by the end of January. Higher risk to yearling SR than young of year.
High- continual exports	Frequenc y of Exposure Low. DCC gates infrequentl y operated in December and January
Medium to High	Magnitu de of Effect Medium- High
Medium to High - effects of hydrody namics well studied and modelled . Effects of hydrody namics	Weight of Evidenc e High- There are a number of publicati ons regardin g the relative survival in various North Delta and Central Delta and Contral Delta migrator y routes; conclusi ons
Reduced survival, reduced growth; likely lesser effect in final PA due to revised loss thresholds, though no loss	Probable Change in Fitness Reduced survival; lesser effect in final PA due to revised DCC operations in December- January

Delta	Division
CVP/SWP South Delta Exports	Action Component
Entrainment and loss at the south Delta export facilities	Stressor/Fact or
Juveniles - Delta	Life Stage (Location)
Juvenile migration and rearing - Dec - May	Timing (Work Window Intersection)
Loss is approximately 35% at the CVP and 84% at the SWP fish salvage facilities	Individual Response and Rationale of Effect transit time and exposure to predators, poor water quality, and contaminants.
Sublethal to Lethal	Severity of of Stressor/ Level of Benefit
Small	Proportion of Population Exposed
High	Frequenc y of Exposure
Medium to High - sustained high frequenc y exposure on small proportio n of populati on	Magnitu de of Effect
High - Numerou s studies have evaluate d the efficienc y of the screenin g facilities, predation , as well as survival through the	Weight of Evidenc e on salmonid migratio ns in south Delta less certain.
reduced survival; likely lesser effect in final PA due to revised loss thresholds, though no loss threshold specific to spring-run.	Probable Change in Fitness specific to spring-run.

Delta	Division Delta
CVP/SWP exports	Action Component DCC Gate operations -
Shift in Operations	Stressor/Fact or Transit times
Juveniles - Sacramento River -Delta	Life Stage (Location) Juveniles - Sacramento River -Delta
Juvenile migration and rearing - Dec - May	Life Stage Timing (Work Window Intersecti on) Juvenile migration and rearing - Dec - May
Shift in exports to CVP from SWP to reduce impacts of predation from the CCF when capacity at CVP exists	Individual Response and Rationale of Effect Increased mortality due to increased migration times with concurrent increased exposure to predators
Benefici al: High	Severity of Stressor/ Level of Benefit Sublethal to Lethal
Small	Proportion of Population Exposed Medium- gates open from Oct 1 through Nov 30, typically closed Dec 1 through Jan 31. Closed Feb 1 through May 20. Estimated 5 % of juvenile SR population emigrates by the end of January
Medium	Frequenc y of Exposure Low. DCC gates infrequentl y operated in December and January
Medium	Magnitu de of Effect Medium to High
Medium - Several studies show lower losses at the CVP for salvaged fish - availabili ty of capacity	Weight of Evidenc e  High-There are a number of publicati ons regardin g the relative survival in various North Delta and Central Delta and Central Delta migrator y routes; conclusi ons supporte d by modellin g results.
Increased survival	Probable Change in Fitness Reduced survival; lesser effect in final PA due to revised DCC operations in December- January

ם	D	
Delta	Delta	Division
DCC Gate operations -	DCC Gate operations -	Action Component
Increased entrainment and loss at the South Delta Exports facilities	Routing	Stressor/Fact
Juveniles - Sacramento River -Delta	Adults - Sacramento River - Delta	Life Stage (Location)
Juvenile migration and rearing - Dec - May	Jan - June	Life Stage Timing (Work Window Intersecti on)
Increased mortality of entrained fish at the CVP and SWP fish salvage facilities	Increased straying into the Mokelumne River system when gates are opened, followed by migratory delays when gates are closed for water quality concerns	Individual Response and Rationale of Effect
Sublethal to Lethal	Minor	Severity of Stressor/ Level of Benefit
Small to Medium	Low - gates opened infrequentl y in January, closed February 1 - May 20	Proportion of Population Exposed
High	Medium	Frequenc y of Exposure
Low - sustained populati on effects on a small to medium proportio n of the populati on present in the Delta	Low	Magnitu de of Effect
High - numerou s studies have evaluate d the potential risk to salmonid s entering the Delta interior and becomin g	Medium - tagging studies related to straying of Chinook through the DCC when open.	Weight of Evidenc e at the CVP is uncertain
reduced survival; lesser effect in final PA due to revised DCC operations in December-January	Delayed migration, possible reduction of spawning success; lesser effect in final PA due to revised DCC operations in December- January	Probable Change in Fitness

Delta	Delta		Division
North Bay Aqueduct	North Bay Aqueduct		Action Component
Entrainment and impingement onto fish screens	Routing		Stressor/Fact
Juveniles - Sacramento River -Delta	Juveniles - Sacramento River -Delta		Life Stage (Location)
Juvenile migration and rearing - Dec - May	Juvenile migration and rearing - Dec - May	,	Life Stage Timing (Work Window Intersecti on)
Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Increased mortality due to routing into the channels of the Lindsey Slough/Barker Slough region		Individual Response and Rationale of Effect
Minor	Minor		Severity of Stressor/ Level of Benefit
Small	Small		Proportion of Population Exposed
High - exports occur on annual basis	High		Frequenc y of Exposure
Low - screens are designed for delta smelt criteria, few salmonid s expected to be	Low- very small proportio n of populati on will be present in Barker Slough, low impacts of diversion volumes on hydrody namics		Magnitu de of Effect
High - monitori ng has few observati ons of Chinook salmon at this location, multiple studies	Medium - few Chinook salmon observed in regional monitori ng efforts in the past. No fish observed behind screens in monitori ng	vulnerabl e to entrainm ent at the fish salvage facilities.	Weight of Evidenc
Minimal change in fitness	reduced survival		Probable Change in Fitness

	r			
Delta	Delta	Delta		Division
CCWD Rock Slough water diversions	North Bay Aqueduct	North Bay Aqueduct		Action Component
routing	Impingement/ capture during aquatic weed cleaning	Entrainment during sediment cleaning		Stressor/Fact
Juveniles - Sacramento River -Delta	Juveniles - Sacramento River -Delta	Juveniles - Sacramento River -Delta		Life Stage (Location)
Juvenile migration and rearing - Dec - May	Juvenile migration and rearing - Dec - May	Juvenile migration and rearing - Dec - May		Life Stage Timing (Work Window Intersecti on)
Delayed migration and increased transit times with potential for increased mortality due to routing into the channel of Rock Slough where predation is likely to be elevated	Injury or death due to impingement, capture by grappling hooks during weed removal	Injury or death due to entrainment into dredge or impingement onto fish screens		Individual Response and Rationale of Effect
Sublethal to Lethal	Sublethal to Lethal	Sublethal to Lethal		Severity of Stressor/ Level of Benefit
Small	small	Small		Proportion of Population Exposed
High - pumping through the Rock Slough diversion occurs every year	Low. Aquatic weeds removed infrequentl y	Low. Sediment removed infrequentl y		Frequenc y of Exposure
Low- medium - small numbers of fish are likely to be in the vicinity of the fish screens and intake	Low - fish unlikely to be in area of screens during cleaning	Low - fish unlikely to be in area of screens during cleaning	present at screen location	Magnitu de of Effect
Medium - annual monitori ng reports indicate that no fish are entrained through the screens, however	Low. No reports or studies available	Low. No reports or studies available	regardin g efficienc y of positive barrier fish screens	Weight of Evidenc
reduced fitness due to delay in migration or increased predation.	minimal change in fitness	Minimal change in fitness		Probable Change in Fitness

-	P	~71	T	
Delta	Delta	Delta		Division
Predator removal studies	Predator removal studies	Water Transfers		Action
capture in sampling gear	capture in sampling gear	Transit times		Stressor/Fact
Juveniles - Sacramento River -Delta	Adults - Delta	Juveniles - Sacramento River -Delta		Life Stage (Location)
Juvenile migration and rearing - Dec - May	Adult migration - Jan - June	Juvenile migration and rearing - Oct - Nov - (yearling SR)		Life Stage Timing (Work Window Intersecti
Increased vulnerability to injury and predation due to entanglement/en trapment in sampling gear	Increased vulnerability to injury and mortality due to entanglement/en trapment in sampling gear	Elevated river flows may reduce transit times through riverine reaches of the Delta		Individual Response and Rationale of Effect
Sublethal to Lethal	Sublethal to Lethal	minor		Severity of Stressor/ Level of Benefit
Small	Small	Small		Proportion of Population Exposed
Low	Low	Low		Frequenc y of Exposure
Low - infreque nt sampling over two to three	Low - infreque nt sampling over two to three years of study	Low		Magnitu de of Effect
Medium - Several reports from previous predator removal	Medium - Several reports from previous predator removal studies, literature on sampling methods.	Low. No reports or studies available	fish are observed in front of the screens, and have been observed in historical monitori ng.	Weight of Evidenc
reduced survival	reduced survival	increased fitness		Probable Change in Fitness

Delta	Delta	Division
Suisun Marsh Roaring River Distribution System Food Subsidy Studies	CVP Improvemen ts	Action Component
Temporary change in water flow/water quality (20 days Oct-May, 60 days June- Sept)	CO2 Injections	Stressor/Fact
Adults and juveniles may migrate through the area on their way to spawning grounds or as outmigratin g juveniles.	Juveniles - Sacramento River -Delta	Life Stage (Location)
Adult migration (Jan – June)Juve nile migration and rearing - Dec - May	Juvenile migration and rearing - Dec - May	Life Stage Timing (Work Window Intersecti on)
During the annual 20 days of periodic operation Oct - May, individual adult spring-run may be delayed in their spawning migration from a few hours to several days. Juveniles may be delayed on	Small increase in morbidity and mortality due to CO2 exposure during predator clean outs of secondary channel	Individual Response and Rationale of Effect
Minor	Sublethal to Lethal	Severity of Stressor/ Level of Benefit
Low	Small	Proportion of Population Exposed
Low	High	Frequenc y of Exposure
Low	Low	Magnitu de of Effect years of study
Medium- data on Chinook salmon migratio n and rearing in Suisun Marsh is medium, based on a few studies of the	Medium - several studies show effective ness of CO2 in removal of predators and sensitivit y of smaller fish to CO2 exposure	Weight of Evidenc e studies, literature on sampling methods.
Minimal	Reduced fitness	Probable Change in Fitness

Delta	Division
Sacramento Deep Water Ship Channel Food Study	Action Component
Altered hydrodynamic s and migration routing in the Ship Channel	Stressor/Fact
Adults and Juveniles	Life Stage (Location)
Adult migration (Jan – June)Juve nile migration and rearing - Dec - May	Life Stage Timing (Work Window Intersecti
their downstream movements by closed gates for several hours while gates are closed on flood tides. Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River into Deepwater ship channel when boat locks are open, exposure to reduced water quality in Port of Sacramento and Deepwater ship channel, increased exposure to angling and poaching, predation for juvenile fish	Individual Response and Rationale of Effect
Sublethal to Lethal	Severity of Stressor/ Level of Benefit
Low	Proportion of Population Exposed
Low	Frequenc y of Exposure
Low	Magnitu de of Effect
Salinity gate operation s  Low – little informati on on spring-run migratio n behavior and use within the Sacrame nto Deepwat er ship channel, and Port of Sacrame nto	Weight of Evidenc
Reduced fitness	Probable Change in Fitness

Overall for the Sacramento River basin and Delta (

Table 2.8.3-2), under the PA, there are 35 action components expected to create stressors for various life stages and 13 action components that benefit various life stages. (Table 2.8.3-3).

Table 2.8.3-3. Summary of the number of PA components expected to create stressors or benefits of varying levels of magnitude to listed species as identified in Table 2.8.3-2.

Magnitude Level	Actions Creating Stressors Under the PA	Actions Creating Benefits Under the PA
High ¹	11	2
Medium	4	5
Low	20	6
Total ²	35	13

¹ If the magnitude was a range that included "High" then that stressor or benefit was counted in the "High" category, and not recounted in the "Medium" or "Low" categories.

While the entire suite of adverse and beneficial effects associated with the PA are described in Section 2.5 and summarized above in Table 2.8.3-2 and Table 2.8.3-3, water temperature management, low Sacramento River base flows, DCC gate operations, and CVP/SWP south Delta export operations warrant further exploration as the most significant PA-related factors affecting CV spring-run Chinook salmon. Each of those factors has a high weight of evidence suggesting there will be a high magnitude of effect on at least one life stage for at least one individual spring-run population.

First, water temperature under the PA is expected to be a high magnitude stressor for CV spring-run Chinook salmon in the Sacramento River and Clear Creek. It should be noted that CV spring-run Chinook salmon spawning in the Sacramento River are part of a small dependent population and are introgressed with fall-run Chinook salmon due to environmental baseline factors (large dams) as well as CVP/SWP-related impacts. Clear Creek is considered a Core 1 population in the NMFS salmonid recovery plan, though the population is currently small in most years.

The PA's tiered cold water pool management approach for the Sacramento River, is expected to result in water temperature-dependent egg mortality every year given the water temperature-egg survival relationship and the available information on what water temperatures under the PA are likely to be. Mortality of Chinook salmon eggs in the river is expected to increase quickly as temperatures become warmer than 53.5°F (Swart 2016, Martin et al. 2017). Based on the water temperature modeling results from the ROC on LTO BA, Sacramento River water temperatures at CCR under the PA during CV spring-run Chinook salmon spawning and egg incubation in

² If the magnitude was identified as "Uncertain" or "NA", then that stressor or benefit was not counted. The Sacramento River water temperature stressor was only counted once for its impact on eggs and once for its impact on adults even though there are eight "High" magnitude stressor rows for those stressor-life stage combinations, because each row per life stage corresponds to a different tier and not an additional stressor. Similarly, the "Medium" magnitude beneficial actions related to the single issue of Sacramento River water temperature planning were counted once.

August through October are expected to exceed 53.5°F for 76 percent of the days under tier 1, 80 percent of the days under tier 2, 97 percent of the days under tier 3, and 100 percent of the days under tier 4.

Revisions to the Cold Water Pool Management section of the final PA include the addition of Section 4.10.1.3.3 Upper Sacramento Performance Metrics. The objective of these performance metrics is to ensure that the performance of the PA operations for temperature management falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of winter-run Chinook salmon temperature dependent mortality. This revision affects the CV spring-run Chinook salmon analysis by increasing the certainty that the analysis more accurately characterizes exposure and risk to CV spring-run Chinook salmon due to the PA operations. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which is based on the central tendency to capture the most likely conditions – to be a more accurate characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management do not change quantitatively due to the revisions included in the final PA, as this commitment to assess cold water management does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

Given that the modeling results are likely merely a coarse predictor of actual water temperatures that would occur under the PA, the examination of observed data provides another source of information to frame Sacramento River temperatures under PA implementation. The assumption that observed data on Sacramento River water temperature during August through October is a reasonable indicator of water temperatures that could occur with PA implementation is supported by the facts that: (1) the observed data reflect implementation of current operations; and (2) the modeling results show there is very little difference between the PA and COS water temperatures during those months. Therefore, recent observed data can serve as an indicator for expected water temperatures under the PA for months where the modeled PA and COS water temperatures are similar. In the ROC on LTO BA, Figure 6-1 shows that modeled Sacramento River water temperatures at CCR for the two scenarios are within 1°F of each other, with slightly warmer levels under the PA in September and slightly cooler levels in October, relative to the COS. Based on observed Sacramento River water temperatures at CCR from 2009 through 2018 during August through October, CV spring-run Chinook salmon have been exposed to water temperatures warmer than 53.5°F every year except for 2017. The range varies greatly, between less than 10 or more than 95 of percent of days with August through October water temperatures over 53.5°F in a given year from 2009 through 2017; 45 percent of the days in 2018 were over 53.5°F.

The modeled PA water temperature projections at CCR indicate 76 to 100 percent of the days during the CV spring-run Chinook salmon egg incubation months of August through October are expected to be over 53.5°F every year. Observed data from 2009 through 2018 ranged greatly from 0 to 100 percent, which indicates thermal impacts on CV spring-run Chinook salmon eggs would be worse under the PA than they are in the baseline condition. The PA proposes a water temperature management approach to protect winter run Chinook salmon egg incubation, which may result in warmer temperatures for CV spring-run Chinook salmon egg incubation. The PA proposes to cease providing 53.5°F at CCR when the monitoring working group determines based on real-time monitoring that 95 percent of winter-run Chinook salmon eggs have hatched,

and alevin have emerged, or on October 31, whichever is earlier. Based on both modeling results and observed data from 2009 through 2018, the PA is expected to expose a large proportion of the Sacramento River population of CV spring-run Chinook salmon eggs to water temperatures warmer than 53.5°F as the end of October and November are key periods for egg incubation, resulting in water temperature-dependent egg mortality every year, and likely deepens the harm to this population, relative to baseline conditions.

We do consider the project components that are intended to offer as much protection as practicable in drought or extreme conditions, including the process for development of an annual temperature management plan, the use of conservative forecasts, protection of the third cohort of winter-run Chinook salmon after two consecutive years of poor survival, and specific "at the ready" actions for drought and dry years. The temperature management plan may reduce the likelihood of exceeding the temperature target, which is used in the characterization of exposure to increased temperatures in the analysis. The conservation measures intended to protect the third cohort of winter-run Chinook salmon after two consecutive years of poor survival may allow opportunities for actions to be implemented to reduce temperature-related effects on spring-run Chinook salmon despite the probability of year types that may occur. Finally, NMFS expects a reduction in extreme effects on the species throughout extended drought due to the Drought and Dry Year Actions. We note that potential benefit of a toolkit of actions to be taken in drought conditions, and the process by which early warnings of drought conditions may allow for clear and swift development of a drought contingency plan. We also note that the action to reintroduce spring-run Chinook salmon to their historic habitat upstream of Shasta Reservoir included in the NMFS 2009 Opinion RPA that is not being carried forward as part of this PA would be an important addition to the tool kit to help the species withstand droughts.

Water temperature and biological monitoring in Clear Creek indicate that CV spring-run Chinook salmon eggs are annually exposed to lethal water temperatures considering that the September 15th through October requirement for a daily average of 56°F at Igo has been exceeded almost every year since the requirement was established in the NMFS 2009 Opinion, about half of the CV spring-run Chinook salmon redds occur downstream from the Igo gauge, where they would be exposed to temperatures warmer than 56°F, and based on redd observations dates from 2003 through 2018, an average of 8 percent of CV spring-run Chinook salmon spawning occurs prior to September 15 (Provins 2019a). Additionally, the established 56°F requirement at Igo may not be as protective as intended, based on recent science indicating that Chinook salmon egg mortality increases rapidly at water temperatures warmer than 53.5°F (Swart 2016, Martin et al. 2017). As there is virtually no difference between the modeled PA and COS, this frequent lethality to a large proportion of CV spring-run Chinook salmon eggs in Clear Creek currently occurring, is assumed to represent impacts expected under the PA (Figure 2).

The next key stressor to spring-run Chinook salmon that will result from PA implementation is reduced Sacramento River base flows in the spring, which will limit access to food rich floodplain habitat and reduce juvenile survival. As the pre-dam hydrograph in Figure 2.5.2 2 shows, the median monthly flows for February through April would naturally have been at nearly double the flowrate currently managed to flow into the upper Sacramento in more recent decades. Under the PA minimum winter releases (described in Section 2.5.2.3.1.1 Winter Minimum Flows) will be maintained into the spring and until "flows are needed to support instream demands on the mainstem Sacramento River and Delta Outflow requirements" (U.S. Bureau of Reclamation 2019). Modeling confirms that for both the PA and the COS, early spring

(February – April) flows are maintained at minimum levels to build storage. Keeping flows at Keswick Dam artificially low restricts the river's "natural" physical, biochemical, and ecosystem functions such as floodplain connectivity (Yarnell et al. 2015, Mount et al. 2017), and limits juvenile salmon survival given that flow has repeatedly been the most important factor affecting overall survival of Chinook salmon in the Central Valley (Kjelson and Brandes 1989, Zeug et al. 2014, Michel et al. 2015, Iglesias et al. 2017)

In the Sacramento River, the dynamic natural flows that would result from unregulated tributary contributions have been replaced by a spring base flow – a single minimum instream flow intended to be sufficient to maintain aquatic species during crucial low-flow periods. This is in contrast to the tributaries of the upper Sacramento River, which mostly have unmodified hydrographs subject to a seasonal flow regime. This contrast, between the unmodified flows of the tributaries and the minimum flows in the mainstem, creates a hydrologic disconnect for juveniles migrating out of the tributaries. Juvenile CV spring-run Chinook salmon migration out of Mill and Deer creeks begins in mid-to-late April, extends through May, and is triggered by spring storm events or warming air temperatures causing rapid snowmelt. Peak migration out of these tributaries typically occurs early to mid-May according to 15 years of rotary screw trap data (1995-2010). And while CalSimII modeling of the PA and COS shows Keswick releases increasing in May for the PA, this increase is made in part to satisfy agricultural deliveries which then reduce flows downstream of the point of diversion (i.e., at Wilkins Slough). These diminishing flows are also described in the modeling for both the PA and the COS where average flows at Wilkins Slough in May are approximately 6,500-7,000 cfs, which is 1,200-1,300 cfs lower than flows below Keswick Dam. For those fish originating from Battle, Cottonwood, and Clear creeks, as well as from the mainstem Sacramento River, juvenile migration past RBDD occurs November to May (University of Washington Columbia Basin Research 2019). These fish are therefore subject to the drastically reduced managed winter and spring flow hydrograph and the resulting low flow habitat conditions created by the winter and spring base flows. The spring pulse flow should help offset the otherwise low flow conditions by improving survival, but benefits associated with consistently higher base flows accompanied by floodplain inundation flows will be restricted under the PA.

Under the PA, the DCC gates are expected to be opened more during October and November, and could be opened up to 10 days more during December through January for water quality concerns (compared to up to 3 days for water quality concerns, and some possible openings for experiments, under the COS). However, revisions to the PA not captured in the modeling include (a) the potential for increased fall flows in Above Normal and Wet years for the Fall Delta Smelt Habitat Action, which might reduce the DCC openings under the PA in October and November, and (b) clarifications that these additional DCC gate openings in December and January will only occur when drought conditions are observed (defined in the final, June 14, 2019, PA as "fall inflow conditions are less than 90 percent of historic flows") and modeling shows that DCC opening will avoid exceedance of a water quality concern level. This joint condition is expected to occur in less than 1 in 10 years, and Reclamation and DWR will coordinate with USFWS, NMFS and the SWRCB on how to balance D-1641 water quality and ESA-listed fish requirements. The revised PA also included a new commitment to reduce combined CVP/SWP exports to health and safety levels (1,500 cfs) during any DCC gate opening in December or January. The revisions to DCC operations in the final PA lessens the resulting impacts from the expected impacts of the PA as first communicated by Reclamation to NMFS. During the months

of operation (gates open), approximately 5 percent of juvenile CV spring-run Chinook salmon may be subjected to entrainment where survival is reduced compared to remaining in the Sacramento River migratory route. In particular, yearling CV spring-run Chinook salmon from Mill, Deer, and Butte creeks, and other Sacramento River tributaries supporting the yearling life history strategy that are emigrating during the fall would be exposed to an open DCC gate more frequently under the PA than under the COS. These fish emigrate at larger sizes than juvenile YOY CV spring-run Chinook salmon, and are thus less likely to be observed in the trawls and other monitoring actions due to their ability to avoid them. Yearling spring-run Chinook salmon are expected to enter the Delta after precipitation events in the upper Sacramento River basin increase flows in the tributaries and the mainstem Sacramento River and stimulate the yearling CV spring-run to start emigrating downstream. This may occur as early as October and extends through January and February. These fish would likely encounter the open DCC gates prior to December 1, and anytime the gates are opened from December 1 through January 31 for water quality issues.

The PA also extends the number of days transfers can occur (transfer window) for project and non-project water supplies through CVP and SWP. This PA component potentially affects all life stages of CV spring-run Chinook salmon, and increases the risk of entrainment, particularly juveniles, into the export facilities, increasing the risk of mortality to exposed fish.

Modeled OMR flows under the original PA will be approximately 3,500 to 4,000 cfs more negative during April and May in wetter water year types with the elimination of the San Joaquin inflow-to-export ratio under RPA action IV.2.1. In drier years (below normal and dry water year types) the differences between the PA and COS were less, but were still approximately 1,500 cfs more negative under the PA conditions as compared to the COS conditions. In critical water year types, the PA was modelled to be 600-800 cfs more negative than the COS conditions. Seldom during the April and May period are modelled OMR flows predicted to be more positive/less negative under the PA than under the COS conditions, and positive OMR flow values occur in April and May less frequently under the PA (<10 percent of years) compared to the COS (approximately 50 percent of years). The more negative OMR flows are a direct response to increased exports during this period of time (particularly in April and May). The salvage density modelling shows that, under the original PA, the increased exports will lead to substantially more loss at the CVP and SWP for spring-run Chinook salmon, relative to the COS (

### Table 2.8.3-4). The loss estimates presented in

Table 2.8.3-4 (below) do not include loss due to louver cleaning and do not include predation observed to occur on the upstream side of the TFCF trash racks (Vogel 2010), or far-field mortality associated with altered hydrodynamics, and therefore underestimate mortality associated with south Delta pumping and CVP/SWP fish salvage facilities.

While loss is still expected to occur under the final PA, NMFS notes that the revised loss thresholds in the June 14, 2019 PA are expected to limit risks associated with the near-field effects (entrainment into and loss at the export facilities) to levels less than estimated using the Salvage Density Model results described in Section 2.5.5.8.3.1. The intent of the loss thresholds is to limit loss of all ESA-listed species to levels comparable to loss observed under the COS. However, because the only loss threshold in effect during April-June 15 is for natural steelhead, the revised loss thresholds in the final PA only indirectly provide protections for outmigrating young-of-year CV spring-run Chinook salmon during this period. The final PA includes triggers for review and technical assistance anytime observed loss exceeds average annual historical loss, which provide some assurance that species risks will be conservatively managed. The Salvage

Density Model shows the greatest differences in the PA vs. the COS during April and May, when winter-run Chinook salmon have largely exited the Delta, and the revised loss thresholds are expected to provide an incremental level of additional protection relative to the original PA during this period.

Even under the revised PA, mortality of CV spring-run Chinook salmon is expected due to direct loss, which includes pre-salvage mortality from both pre-screen loss and imperfect fish guidance efficiency at louvers or screens. Far-field mortality associated with south Delta pumping and fish salvage operations is also expected under the final PA. It is less certain whether the revised loss thresholds in the final PA will fully limit risks associated with the far-field effects (potential disruptions to migration rate or route) of the export facilities that may lead to mortality. Because NMFS assumes that far-field effects are correlated with exports (both footprint and magnitude of hydrodynamic effect greater at higher exports), limiting near-field effects to historical rates could be assumed to limit far-field effects to historic rates. However, if OMR (and associated Delta hydrodynamics) is more negative under the final PA than observed under the COS, far-field effects under the final PA are expected to be intermediate between the COS and the original PA. Because exports and associated OMR flows in the original PA and COS scenario are most different in April-May, far-field effects intermediate between the COS and the original PA are most likely to affect spring-run migrants passing through the Delta in April and May.

NMFS put the combined CV spring-run Chinook salmon loss at the CVP and SWP in a screening-level population context (see caveats in Section 2.5.5.8.3.1) by expressing the estimated annual combined loss as a percentage of the juvenile CV spring-run Chinook salmon entering the Delta. Assuming that the relationship between spring-run Chinook salmon escapement and the number of juveniles entering the Delta is similar to that for winter-run Chinook salmon (Table 2.5.5 37.5), the observed brood year 2010-2018 tributary CV spring-run Chinook salmon escapement range of 1,059 to 19,516 is estimated to produce 35,334 to 3,837,720 juvenile CV spring-run Chinook salmon entering the Delta. The estimated annual combined loss from the COS is 851 juveniles, and estimated annual combined loss from the PA is 1,732. Applying the estimated annual combined loss to the lowest and highest juvenile population estimates provides ranges of <1 (851  $\div$  3,837,720) to 2 (851  $\div$  35,334) percent loss of the juvenile CV spring-run Chinook salmon population in the Delta for the COS, and <1 (1,732 ÷ 3,837,720) to 5 (1,732 ÷ 35,334) percent loss of the juvenile CV spring-run Chinook salmon population in the Delta for the PA. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable with the COS scenario, though there is not specific loss threshold for spring-run Chinook salmon. Thus, the estimated screening-level population context under the final PA is likely less than the <1 to 5 percent estimated under the original PA.

Table 2.8.3-4. Estimated adjusted loss of juvenile CV spring-run Chinook salmon for the February 5, 2019, PA and COS scenarios at the SWP/CVP fish salvage facilities – by water year type. Revised loss thresholds in the June 14, 2019 PA may limit loss to be more comparable with the COS scenario, though there is not specific loss threshold for spring-run Chinook salmon.

Water Year Type	CVP/SWP Loss			
	PA	COS	PA-COS	% change
Wet	1,732	851	881	104
Above Normal	1,193	461	732	159

Water Year Type	CVP/SWP Loss			
	PA	COS	PA-COS	% change
Below Normal	234	116	117	101
Dry	482	278	205	74
Critical	249	153	97	64

High magnitude beneficial effects of the PA are expected with implementation of the Sacramento River spring pulse flow component and the use of CO₂ injection to remove predators from secondary channel at the TFCF. The spring pulse flow action is expected to improve survival of multiple juvenile spring-run Chinook salmon populations in the Sacramento River basin. Similarly, increased survival of multiple juvenile populations is expected to improve with predator removal at the TFCF, although the long-term efficiency of this method is not certain. These high magnitude beneficial actions are not expected to off-set decreases in survival under the PA related to thermal impacts at the egg stage and juvenile mortality associated with increased entrainment into the central Delta through the DCC and increased exports.

Additionally, the continued partnership among the Northern California Water Association, the Western Shasta Resource Conservation District, the Sacramento River Forum, Chico State University, local landowners, and the five agency family of CDFW, DWR, NMFS, USFWS, and Reclamation will result in benefits to spawning success and production associated with increasing the quantity and quality of spawning substrate in the upper Sacramento River; benefits to rearing and migrating juvenile fish associated with the installation of fish screens and the construction of side-channel and in-channel habitat structures; and benefits to adult migrants and rearing and migrating juvenile fish from the construction of fish passage projects. The SRSC commitment to the scope, mission and objectives of the Sacramento River Science Partnership is expected to improve the science that is used to protect and support the recovery of CV spring-run Chinook salmon.

### 2.8.3.3 Assess Risk to the Population

NMFS assesses the risk to CV spring-run Chinook salmon populations expected to occur with implementation of the PA by evaluating how the collective suite of PA factors and stressors is expected to impact the VSP parameters (see Figure 2.1.3-6). The availability, diversity, and utilization of properly functioning habitats and the connections between such habitats provides the foundation for a viable, resilient population (Figure 2.4.1-3) (McElhany et al. 2000, Herbold et al. 2018). Below, the PA's impact on CV spring-run Chinook salmon habitat capacity and diversity, spatial structure, diversity, abundance, and productivity are discussed in turn. Because of the nonessential experimental population designation of SJRRP spring-run Chinook salmon, it is not essential to the continued existence of the listed CV spring-run Chinook salmon ESU. Therefore, NMFS does not assess risk to this population.

### 2.8.3.3.1 Spatial Structure

As described in Section 2.5 and summarized in Table 2.8.3-2 and Table 2.8.3-3, going from north to south, CV spring-run Chinook salmon habitat conditions in the Sacramento River, Clear Creek, and the Delta and the lower San Joaquin River are negatively affected by the PA in a number of ways. A few key examples include: (1) making releases that result in lethal water temperatures for eggs in all years, resulting in particularly high mortality in drier years in the

Sacramento River and Clear Creek; (2) mortality of rearing and outmigrating juveniles from fluctuating Sacramento River flows while using Sacramento River floodplain and side-channel habitats when flows are high, and then isolated when flows are reduced; affecting juveniles originating from multiple CV spring-run Chinook salmon populations in the upper Sacramento River basin (e.g., Sacramento River, Clear, Battle, Antelope, Mill, and Deer creeks); and (3) increased exports during April and May which increases direct loss at the south Delta export facilities and also creates hydrodynamic conditions expected to result in detrimental outmigration conditions and decreased survival by increasing the exposure of juvenile CV spring-run Chinook salmon to predation and poor water quality. The reductions in habitat quantity and quality caused by the PA, relative to the COS, limit the population's spatial structure, which is expected to have greater adverse impacts to CV spring-run Chinook salmon genetic and phenotypic diversity, than the COS (McElhany et al. 2000, Herbold et al. 2018).

### 2.8.3.3.2 Diversity

The diversity of CV spring-run Chinook salmon continues to be limited as a result of the PA, and is likely to be further reduced by the proposed water temperature management for the Sacramento River and south Delta exports. On the Sacramento River, CV spring-run Chinook salmon eggs incubating during November are likely to suffer greater losses than eggs that were spawned early, developed, and emerged from the river before water temperature management ceased on October 31 or earlier. This would skew the window for successful CV spring-run Chinook salmon spawning and egg incubation so that the earliest spawners have a higher chance of their off-spring surviving. Decreasing life history diversity in that way goes against the portfolio effect concept that is important for population resilience (Herbold et al. 2018).

The PA also reduces CV spring-run Chinook salmon life history diversity and population resilience through the south Delta export operations. The PA proposes to increase total exports during the period from January to June and, in particular, during drier water year types. The most dramatic increases in the original PA occur during April and May, though the revised loss thresholds and multiple process steps in the final PA provide some assurance that species risks will be conservatively managed. Nonetheless, juvenile CV spring-run Chinook salmon migrating through the Delta in April and May would likely be exposed to altered hydrodynamic conditions caused by an increase in exports relative to current operations, resulting in higher salvage and associated mortality relative to juveniles emigrating before April. Reduced survival of CV spring-run Chinook salmon emigrants in April and May constricts life history diversity and also has important implications for cohort productivity. Because the timing and quality of conditions in the Bay-Delta and marine environments are highly variable, a diverse portfolio of juvenile sizes migrating at different times increases the chances that some fraction of each annual cohort will be able to capitalize on suitable conditions in those environments (Herbold et al. 2018, Stanislaus River Scientific Evaluation Process (SEP) Team 2019).

### 2.8.3.3.3 Abundance

As summarized above in Section 2.8.3.2, and fully described in Section 2.5 Effects of the Action, the PA will impose high magnitude stressors in the Sacramento River, Clear Creek, and the Delta that will result in sublethal and lethal impacts, particularly on the egg, fry, and juvenile life stages. The PA will likely reduce the abundance of the Sacramento River and Clear Creek populations by exposing eggs to water temperatures associated with higher egg mortality in those

watersheds, as well as reducing all rearing and outmigrating Sacramento River Basin CV spring-run Chinook salmon populations by entraining juveniles into the central Delta through the DCC, entraining and impinging juveniles at the CVP and SWP fish salvage facilities (both direct and indirect loss), and processing juveniles through the collection, handling, transport, and release (CHTR) program. When the expected mortality at the egg and juvenile life stages are considered on top of the Delta mortality, population level reductions in abundance caused by PA implementation are all but a certainty for CV spring-run Chinook salmon populations in the Sacramento River and Clear Creek.

### 2.8.3.3.4 Productivity

CV spring-run Chinook salmon productivity (population growth rate) is evaluated using trends in spawner abundance (Lindley et al. 2007), specifically focusing on the rate of decline in spawner abundance. The rationale behind the population decline criteria are fairly straight forward: severe and prolonged declines to small run sizes are strong evidence that a population is at risk of extinction. Population growth (or decline) rate is estimated from the slope of the natural logarithm of spawners versus time for the most recent 10 years of spawner count data. High extinction risk under this criterion is defined as a population declining within last two generations to annual run size less than or equal to 500 spawners, or a run size greater than 500 but declining at greater than or equal to 10 percent per year; moderate risk is a population undergoing chronic decline or depression such that the run size has declined to less than or equal to 500, but has stabilized; and low risk is when no decline in run size is apparent (Lindley et al. 2007).

It is likely that the reductions in abundance at the egg and juvenile life stages under the PA previously discussed would constrain year class productivity, but given the inherent variability in population abundance over time, it is difficult to infer how the PA's impact on population growth or decline relate to the criteria. No such inferences are made here.

### 2.8.3.4 Assess the Risk to ESU/DPS

The risk to the CV spring-run Chinook salmon ESU posed by the PA is evaluated in the aggregate context of the effects of the PA itself, the species' status, the environmental baseline, cumulative effects, and effects from interrelated and independent actions. The effects of the PA are expected to cause additional harm to the ESU, which is already at high extinction risk due to a harmful environmental baseline. While several factors contribute to that harmful environmental backdrop, the construction and operation of the CVP/SWP is prominent (Cummins et al. 2008, Hanak et al. 2011, National Marine Fisheries Service 2014b). As descried in the Environmental Baseline (Section 2.4.1.3), there is broad scientific support attributing the ecological crisis in the Delta in large part to CVP/SWP water exports from the south Delta (California Department of Fish and Game 2010b, State Water Resources Control Board and California Environmental Protection Agency 2010, Hanak et al. 2011, State Water Resources Control Board 2017b). The PA would increase CVP/SWP water exports in the Delta relative to current operations (Figure 2.8.1-3), likely exacerbating the ecological crisis in the Delta and increasing spring-run Chinook salmon mortality by a range of 64 to 159 percent (

Table 2.8.3-4).

The continued operation of the CVP/SWP as proposed in the ROC on LTO BA does not improve the prospects for the ESU, and based on the effects and VSP-based analyses, is expected to decrease its likelihood of survival and recovery.

The likelihood of survival and recovery is expected to decrease not only due to additional stressors under the PA. For example, this transition would eliminate protections against Delta export impacts (e.g., RPA action IV.2.1).

The PA is expected to reduce the abundance, spatial structure, and diversity of CV spring-run Chinook salmon in the northwestern California and Basalt and Porous Lava diversity groups, further compromising the capacity of the ESU to respond and adapt to environmental changes. California's human population growth (see Section 2.7 Cumulative Effects) and the associated increase in water demand and climate change will exacerbate risks associated with the PA, further increasing the risk to the population. In particular, the water temperature impacts expected with PA implementation are likely to be amplified by climate change.

Considering the effects of the PA, cumulative effects and effects from interrelated and interdependent actions in the context of the status and environmental baseline of spring-run Chinook salmon, NMFS concludes that the PA is likely to appreciably reduce the likelihood of both the survival and recovery of the CV spring-run Chinook salmon ESU (Table 2.8.3-5).

Table 2.8.3-5. Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on the Central Valley Spring-run Chinook Salmon ESU. Dark shading indicates selection. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and not likely/likely to jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if	True/False	Action
	The proposed action is not likely to produce stressors that have direct or indirect adverse effects on the environment	True	End
Α	Available Evidence: The PA will produce multiple stressors that will adversely affect CV spring-run Chinook salmon including, but not limited to: (1) warm water temperatures in the Sacramento River and Clear Creek; (2) low spring flows in the Sacramento River; (3) increased water routing through the DCC; and (4) increased exports at the south Delta export facilities.	False	Go to B
	Listed individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the	True	NLAA
В	Available Evidence: The PA will expose individuals to multiple stressors, including but not limited to: (1) water temperatures warmer than life stage requirements in the Sacramento River and Clear Creek during spawning and egg incubation; (2) low spring flows in the Sacramento River; (3) increased entrainment into the central Delta through the Delta Cross Channel gates; and (4) increased entrainment at the south Delta export facilities.	False	Go to C
С		True	NLAA

Step	Apply the Available Evidence to Determine if	True/False	Action
	Listed individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action  Available Evidence: The PA will produce multiple stressors that individuals will respond to, including but not limited to: (1) water temperature dependent egg mortality and sublethal effects due to warm water temperatures in the Sacramento River and Clear Creek; (2) reduced growth and survival associated with low spring flows in the Sacramento River; (3) increased mortality associated with increased entrainment into the central Delta through the Delta Cross Channel gates; and (4) increased mortality associated with increased entrainment at the south Delta export facilities.	False	Go to D
	Any responses are not likely to constitute "take" or reduce the fitness of the individuals that have been exposed	True	NLAA
D	Available Evidence: The PA will produce multiple stressors, including but not limited to: (1) warm water temperatures in the Sacramento River and Clear Creek; (2) low spring flows in the Sacramento River; (3) increased entrainment through the DCC; and (4) increased exports at the south Delta export facilities that are expected to reduce survival and the overall fitness of individuals which would result in "take."	False	Go to E
	Any reductions in individual fitness are not likely to reduce the viability of	True	NLJ
Е	Available Evidence: The combined effects of the PA are expected to sufficiently reduce the survival and/or reproductive success of CV springrun Chinook salmon individuals at multiple life stages such that key population parameters (i.e., abundance, spatial structure, and diversity) for multiple populations will be appreciably reduced. Reductions in these parameters will likely reduce the viability of CV spring-run Chinook salmon in the Sacramento River and Clear Creek.	False	Go to F
	Any reductions in the viability of the exposed populations are not likely to	True	NLJ
F	Available Evidence: Given that an expected appreciable reduction in any single population's viability due to implementation of the PA would also appreciably reduce viability at the species level, the expected reduction in the viability of Sacramento River and Clear Creek spring-run Chinook salmon would reduce the viability of the CV spring-run Chinook salmon ESU.	False	LJ

### 2.8.4 Central Valley Spring-Run Chinook Salmond Critical Habitat

### 2.8.4.1 Status of Critical Habitat and Environmental Baseline

Within the range of the CV spring-run Chinook salmon ESU, biological features of the designated critical habitat that are considered vital for CV spring-run Chinook salmon include freshwater spawning sites, freshwater rearing sites, water quantity and floodplain connectivity, water quality and forage, natural cover, freshwater migration corridors, and estuarine areas. As

generally described above in Section 2.2 Rangewide Status of the Species and Critical Habitat, the status of critical habitat in each of these PBFs is considered to be highly degraded. The quality of spawning habitat used by CV spring-run Chinook salmon in the mainstem Sacramento River is diminished when fall-run Chinook salmon, which commence spawning slightly later in the season than spring-run Chinook salmon, arrive at the spawning grounds, move gravels around for redd construction, and physically disturb CV spring-run Chinook salmon redds during that process. Spawning and egg incubation habitat for CV spring-run Chinook salmon in the mainstem Sacramento River is often negatively affected by operation of the CVP through warm water releases from Shasta Reservoir. Freshwater rearing and migration habitats have been degraded which delay upstream migration, reduce the availability of quality rearing habitat, and create improved feeding opportunities for predators such as pikeminnow and striped bass. Additional negative effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through flow regulation, levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

As described in Section 2.2 Rangewide Status of the Species and Critical Habitat, the geographical range of designated critical habitat for CV spring-run includes stream reaches of the Feather, Yuba, and American rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; and the Sacramento River downstream to the Delta, as well as portions of the northern Delta. CV spring-run Chinook salmon critical habitat is composed of four PBFs that include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine habitat. As generally described above in Section 2.2, the status of critical habitat in each of these biological features is considered to be highly degraded, particularly with respect to habitats within the mainstem Sacramento River.

Stressors to CV spring-run Chinook salmon critical habitat PBFs include water diversions and water management, dams and other structures, loss of floodplain connectivity, loss of natural riverine function, bank protection; dredging, sediment disposal, gravel mining, invasive aquatic organisms, and agricultural, urban, and industrial land use (McEwan 2001)(McEwan 2001). Spawning and egg incubation habitat for CV spring-run in the mainstem Sacramento River is negatively affected by operation of the CVP through warm water releases from Shasta Reservoir. Freshwater rearing and migration habitats have been degraded which delay upstream migration, reduce the availability of quality rearing habitat, and create improved feeding opportunities for predators such as pikeminnow and striped bass. Additional negative effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through flow regulation, levee construction, loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use. Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of CV spring-run critical habitat is degraded, and does not provide the conservation value necessary for the survival and recovery of the species.

### 2.8.4.2 Summary of Proposed Action Effects

PA-related effects to CV spring-run Chinook salmon designated critical habitat are described within their respective diversity group (Table 2.8.4-1). All CV spring-run Chinook salmon diversity groups must pass through the Delta in their migrations to and from the Pacific Ocean.

The effects of the PA on designated critical habitat in the Delta are summarized in the table below. Detailed descriptions regarding the exposure, response, and risk to CV spring-run Chinook salmon from these stressors are presented in Section 2.6.

Table 2.8.4-1. Summary of proposed action-related effects on spring-run Chinook salmon Critical Habitat organized by division component.

Division	Shasta Shasta
Action Component	Spring Pulse Flow  Summer Cold Water  Management
Location of Effect	Upper Sacramento River  Upper and middle Sacramento River
PBFs Affected	Availability of clean gravel for spawning substrate, Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater Spawning Sites Water temperatures for successful spawning, egg incubation, and fry development, Freshwater Spawning Sites
Response and Rationale of Effect	Spring pulse flows could provide flows high enough to flush fine sediments from spawning substrates.  Temperatures in excess of 53.5°F can lead to sublethal and lethal affects to eggs and larvae.
Magnitude	Medium High
Weight of Evidence	Medium: Correlation of flow and migration supported by multiple scientific and technical publications but magnitude of benefit uncertain.  High: Supported by multiple scientific and technical publications that include quantitative models specific to the region
Probable Change in PBF Supporting the Life History Needs of the Species	Increased or improved quantity/quality of spawning substrate  Decreased access to suitable water temperatures

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History Needs of the Species
Shasta Shasta	Fall and Winter Refill and Redd Maintenance Fall and Winter Refill and Redd Maintenance	Upper Sacramento River  Upper Sacramento	Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater Spawning Sites Adequate river flows for	Increased habitat carrying capacity (WUA) at lower flows providing increased feeding conditions, and decreased competition and predation.  Decreased month to month flows resulting	Low	High: Supported by multiple scientific and technical publications specific to the region and species. Quantitative results include WUA analysis.  Medium: Supported by	Increased habitat carrying capacity necessary for successful spawning, incubation of eggs, fry development and emergence  Decreased flow limiting the
Shasta	Fall and Winter Refill and Redd Maintenance	Upper Sacramento River	Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater Spawning Sites	Decreased month to month flows resulting in stranding caused by a loss of floodplain inundation and sidechannel habitat.	Medium	Medium: Supported by select technical publications specific to the region and species. Quantitative results include month to month change.	Decreased flow limiting the downstream transport of juveniles

Shasta F	Shasta	Shasta	Division
Fall and Winter Refill and Redd Maintenance	Side-Channel habitat	Spawning Gravel Injection	Action Component
Upper Middle Sacramento River	Upper Middle Sacramento River	Upper Sacramento River	Location of Effect
Riparian habitat that provides for successful juvenile	Availability of clean gravel for spawning substrate, Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater Spawning Sites	Availability of clean gravel for spawning substrate, Freshwater Spawning Sites	PBFs Affected
Increased habitat carrying capacity (WUA) at lower flows providing increased feeding conditions, and	As part of adaptive management reclamation would implement side-channel habitat restoration project(s) in the action area. This action component would directly affect access to areas suitable for spawning which includes increased flow to those areas as well as the quantity and quality spawning substrate.	As part of adaptive management reclamation would implement spawning gravel injection project(s) in the action area. This action component would directly affect the quantity and quality of available substrate suitable for spawning.	Response and Rationale of Effect
Low	Low (Uncertain)	Low (Uncertain)	Magnitude
Medium: Supported by technical publications specific to the	Low: (Programmatic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Low: (Programmatic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Weight of Evidence
Increased access to riparian habitat that provides for successful juvenile	Increased or improved quantity/quality of spawning substrate in freshwater spawning sites	Increased or improved quantity/quality of spawning substrate	Probable Change in PBF Supporting the Life History Needs of the Species

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History Needs of the Species
			development and survival, Freshwater Rearing Sites	decreased competition and predation.		region and species. Quantitative results include WUA analysis	development and survival
						and month to month floodplain inundation.	
DIASIA	Redd Maintenance	Sacramento River	flows for successful spawning, incubation of eggs, fry development	September and November resulting in increased travel time and a decrease in survival because of increased predator	менш	Supported by select technical publications specific to the region and species.	limiting the downstream transport of juveniles
			and downstream	iniciacuons.		results include month to month	
			transport of juveniles, Access downstream so			change.	
			that juveniles can migrate from the				
			spawning grounds to San Francisco Bay				
			and the Pacific Ocean,				
			Freshwater Migration				
			Corridors				

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History Needs of the
							Species
Shasta	Small Screen Program	Middle Sacramento	Access downstream so	Framework programmatic action	Low (Uncertain)	Low: (Programmatic	and through
		River	that juveniles	component.		action	Freshwater Migration
			can migrate	Construction activities		component)	Corridors
			from the	are not described but		very little	
			spawning	operation is assumed to		information	
			grounds to San	comply with NMFS		available as to	
			Francisco Bay	and CDFW tish		how or where	
			Ocean	a		Component	
			Freshwater			would be	
			Migration			implemented or	
			Corridors			the extent of its	
						effects.	
Shasta	Lower Intakes near Wilkins	Middle	Access	Framework	Low	Low:	increased access to
	Slough	Sacramento	downstream so	programmatic action	(Uncertain)	(Programmatic	and through
		River	that juveniles	component.		action	Freshwater Migration
			can migrate	Construction activities		component)	Corridors
			from the	are not described but		very little	
			spawning	operation is assumed to		information	
			grounds to San	comply with NMFS		available as to	
			Francisco Bay	and CDFW fish		how or where	
			and the Pacific	screening guidance.		this action	
			Ocean,			component	
			Freshwater			would be	
			Migration			implemented or	
			Corridors			the extent of its	
						effects.	

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History Needs of the Species
Shasta	Adult rescue	Middle Sacramento River	Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River, Freshwater Migration Corridors	Framework programmatic action component. Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of adult salmonids entrained in water diversions (e.g. Yolo and Sutter Bypasses).	Low (Uncertain)	Low: (Programmatic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	increased access to and through Freshwater Migration Corridors
Trinity (Clear Creek)	Water temperature management: Fall	Clear Creek	Fresh water spawning sites	Spawning temperature criterion (56°F) is suboptimal and exceedance further degrades spawning habitat. Greatest impact to habitat downstream of compliance point, and in Critical water year types.	High	Medium	Reduced quality of spawning habitat.
Trinity (Clear Creek)	Minimum instream base flows	Clear Creek	Fresh water spawning sites	Base flows provide suitable spawning habitat, but lack variation that provides habitat complexity. In Critical water year types, reduced base flows will degrade spawning habitat.	Medium	Medium	Reduced quality of spawning habitat.

migratory habitat.	Trough and	100	adult migration, or juvenile emigration near mouth.	migration	Civil Civin	management: Summer	Creek)
rearing habitat	Modium	Tow	temperature criterion (60°F) downstream of compliance point degrades juvenile rearing habitat.	rearing sites	Clartorak	management: Summer	Creek)
Reduced quality of	Medium	Low	compliance point degrades adult holding habitat.  Exceedance of water	Fresh water	Clear Creek	Water temperature	Trinity (Clear
Reduced quality of holding habitat in migratory corridor	Medium	Medium	Exceedance of water temperature criterion (60°F) downstream of	Freshwater migration corridors	Clear Creek	Water temperature management: Summer	Trinity (Clear Creek)
Improved migratory corridor conditions for adults and juveniles.	Medium	Medium	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Freshwater migration corridors	Clear Creek	Spring attraction pulse flows	Trinity (Clear Creek)
Reduced quality of migratory habitat for adults and juveniles.	Low	Medium	Base flows provide enough water to keep the migratory corridor free of obstructions. Flows may lack variability, especially in dry years where there is little input from tributaries or pulse flows, needed to provide turbid conditions and alternative passage routes.	Freshwater migration corridors	Clear Creek	Minimum instream base flows	Trinity (Clear Creek)
Probable Change in PBF Supporting the Life History Needs of the Species	Weight of Evidence	Magnitude	Response and Rationale of Effect	PBFs Affected	Location of Effect	Action Component	Division

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History
							Needs of the Species
Trinity (Clear Creek)	Water temperature	Clear Creek	Freshwater	Decreased water	Low	Medium	Improved migratory
Cleek)	пападенен, ган		corridors	improve conditions			for juveniles.
				for migration.			
Trinity (Clear	Minimum instream base	Clear Creek	Fresh water	Lack of flow	Low	Medium	Reduced quantity and
Cleek)	Hows		rearing sites	reduced habitat			habitat
				complexity. In Critical			
				years, reduced base			
				flows will reduce			
				available rearing			
Trinity (Clear	Channel maintenance nulse	Clear Creek	Fresh water	Pulse flows mobilize	Low	Low	Temporarily improve
Creek)	flows		rearing sites	some gravel to form	A COMMITTEE OF THE PARTY OF THE		connectivity and
				new habitat, and will			increase available
				rearing habitat			rearing habitat.
				availability.			degradation of
				Magnitude, duration,			rearing habitat if
				and frequency is not			flows are not of
				enough to shape the			the channel
				channel and inundate			
				floodplains to improve			
				or increase rearing			
				habitat long-term.			
Trinity (Clear	Channel maintenance pulse	Clear Creek	Fresh water	Pulse flows mobilize	Low	Medium	Some increase in
Creek)	flows		spawning sites	and disperse some			quality and quantity
				spawning gravel, and decrease fines, which			of spawning habitat
				can improve spawning			degradation of
				habitat. Magnitude and			spawning habitat if
				duration are not likely			flows are not of
				to be great enough to			magnitude to shape
				shape the channel and			the channel.

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect spawning gravel and	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History Needs of the Species
				spawning gravel and improve spawning habitat.			
Trinity (Clear Creek)	Channel maintenance pulse flows	Clear Creek	Freshwater migration corridors	Pulse flows increase turbidity, decrease barriers, and increase passage routes.	Low	Low	Improve migratory corridor conditions temporarily
Trinity (Clear Creek)	Spring attraction pulse flows	Clear Creek	Fresh water rearing sites	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability.	Low	Low	Temporarily improve connectivity to rearing habitat.
Trinity (Clear Creek)	Spring attraction pulse flows	Clear Creek	Fresh water spawning sites	Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which can improve spawning habitat.	Low	Medium	Increase in quality and quantity of spawning habitat.
Delta	DCC Gate operation	Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults: Sacramento River, Delta, and SF Bay (Keswick	Freshwater migratory habitat for migrating juveniles from upstream locations to the San Francisco Estuary.	1) Access to the interior Delta through open DCC gates reduces the survival of migrating juveniles, reduces the value of the mainstem migratory corridor. 2) Operations of the DCC gates can alter the extent of tidal	High - Open gates will redirect a portion of the Sacramento River flow into the Delta interior, negatively impacting downstream	High - Multiple peer reviewed studies and reports, coupled with modelling support conclusions.	Gate operations may provide access to the Delta interior reducing survival of juveniles utilizing these routes. Closing the gates will prevent re-routing into the Delta interior via the DCC gates and enhance downstream

	Division
	Action Component
Dam to GG Bridge).	Location of Effect
	PBFs Affected
influence in the river reaches downstream of the DCC location, delaying migration or re-routing juveniles into alternate migratory routes with lower survival.	Response and Rationale of Effect
flow characteristics for juvenile migration. A proportion of downstream migrating juveniles will be routed into the Delta Interior, reducing survival of migrating fish in routes with more adverse habitat conditions (predation, longer distances and travel time). Adults that stray into the Mokelumne River system due to open gates and then encountering closed gates will be delayed in their upstream migration.	Magnitude
	Weight of Evidence
hydrodynamics and tidal intrusion. Closed gates reduce the probability of adult straying and migration delay by closing off false attractant flows. Lesser effect in final PA due to revised DCC operations in December-January.	Probable Change in PBF Supporting the Life History Needs of the Species

Delta Water Transfer	Delta Water Transfer	Division Action Component
Sacramento River and northern Delta	Sacramento River and northern Delta	Location of Effect
Freshwater migratory corridors	Freshwater rearing habitat with water quality and forage supporting juvenile development	PBFs Affected
Enhanced flows from water transfers can benefit juvenile listed yearling spring-run in fall (October and November) migrating downstream by decreasing travel times, increasing the length of riverine reaches, and muting downstream tidal	1) Improved flow conditions may improve water temperature conditions in the mainstem Sacramento River. 2) Improved flow conditions may improve dissolved oxygen conditions through improved mixing of water column and water surface - air interface. 3) Improved water quality in fall may improve primary and secondary productivity benefitting forage base.	Response and Rationale of Effect
Low- improved flows and water quality elements will affect a small proportion of spring-run (yearlings) emigrating downstream in the fall during the transfer window	Low- improved flows and water quality elements will affect a small proportion of spring-run (yearlings) emigrating downstream in the fall during the transfer window	Magnitude
High, several recent papers using acoustic tag technology have shown the benefits of increased flows in enhancing migration survival	Medium- multiple peer reviewed papers confirm benefits to water quality with increased flows. Effects to primary and secondary productivity from increased flows in Sacramento River less certain.	Weight of Evidence
Improved quality of freshwater migratory habitat during water transfers	Increased flows due to water transfers from upstream reservoir releases will improve water temperatures and water quality conditions in the lower Sacramento River and upper Delta waterways. Effect will be temporary and related to the volume and frequency of transfers.	Probable Change in PBF Supporting the Life History Needs of the Species

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History Needs of the Species
Delta	Barker Slough Pumping Plant/ North Bay Aqueduct	Barker Slough/ Lindsey Slough complex	Freshwater migratory corridor	Operations of NBA/Barker Slough Pumping Plant may delay migration of juveniles due to alterations to flow patterns created by the export of water and thereby inhibiting the mobility of juvenile listed salmonids and reducing their survival.	Low – small volume of exports diverted at the pumping station, location not near waters typically used by spring-run during their emigration through the Delta	Low – lack of information regarding the effects of the water diversion on local hydrodynamics.	Reduced quality of migratory habitat for juvenile spring-run Chinook salmon
Delta	2.5.6.8.1.1.1 Fall Delta Smelt Habitat (X2)	Suisun Marsh and vicinity	Spring-run PBFs: access to spawning areas, freshwater rearing sites, freshwater migratory corridors, and estuarine areas.	The action may result in changes to low salinity location, flow volume, and water temperatures. A small change in low salinity zone (X2) location would likely result in minimal effects to spring-run critical habitats. Water temperatures may be altered have an effect on prey abundance, water quality, and migration corridor. Short-term changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG are not expected to significantly change habitat availability or	Low	Low	Low

Delta  2.5.6.8.1.1.4 North Delta Food Subsidies / Colusa Basin Drain and Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Delta  2.5.6.8.1.1.3 Sacramento Deep Water Ship Channel Food Study	Division Action Component
North Delta	SDWSC downstream of Cache Slough complex to Sacramento River confluence	Location of Effect
Spring-run PBFs: freshwater migratory corridors, water quality, forage, freshwater rearing sites.	Spring-run PBFs: freshwater migratory corridors free of obstructions, water quality and forage, and rearing habitat.	PBFs Affected
Water quality would be temporarily affected by the Colusa Basin drainage into the N Delta which would temporarily expose fish to agricultural drainage water potentially containing contaminants (pesticides, nutrients) during 2 months of the year. Exposure would be limited and temporary and would not likely affect	of listed anadromous salmonids.  Reconnecting the SDWSC to the Sacramento River will allow flow through the ship channel which will improve conditions (water temp, flow), but will impact habitat downstream by mobilizing contaminants and other water quality parameters.	Response and Rationale of Effect
Low	Low	Magnitude
Low	Low	Weight of Evidence
Low	Low	Probable Change in PBF Supporting the Life History Needs of the Species

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Supporting the Life History Needs of the Species
Delta	2.5.6.8.1.1.4 Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Suisun Marsh	Spring-run PBFs: freshwater migratory corridors, water quality and forage, freshwater rearing sites, and migratory corridors free of obstructions.	Fish passage will be affected by the operation of the SMSCG. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 70-80 days of annual operation. However, these changes in water flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Short-term changes in tidal flow are not expected to significantly change habitat availability or suitability	Low	Low	Low

### 2.8.4.3 Impact to the Critical Habitat of the Species at the Designation Level

Implementation of the PA is expected to negatively affect CV spring-run Chinook salmon critical habitat in several ways. The PA produces stressors to spawning, rearing, and migratory habitat PBFs in the Sacramento River from the Shasta cold water pool management action. Those stressors include exposure to warm water temperatures during egg incubation and juvenile rearing, DCC operations, and loss of natural river function and morphology affecting all habitat types and rearing habitat quantity and quality. During the proposed fall and winter refill and redd maintenance action, access to riparian habitat in the upper middle Sacramento River may improve, which increases successful juvenile development and survival, however, decreased flows may limit downstream juvenile migration.

Water temperatures are also expected to be exceeded in Clear Creek during summer and early fall months. These warmer temperatures are expected to further degrade the quality of rearing and spawning habitat PBFs for CV spring-run Chinook salmon.

Rearing and migratory habitat PBFs are expected to be degraded by DCC gate operations (though to a lesser extent under the final PA which includes revisions to DCC gate operations). Opening the radial gates allows access to the Delta interior through a manmade channel, which diminishes the functionality of the rearing and migratory quality of the mainstem Sacramento River from its original configuration. Without the DCC, there is no connection to the interior Delta at this location. Providing an artificial route into the Delta interior, allows access to habitat that has reduced survival value compared to the mainstem Sacramento River channel. In contrast, the proposed extension of the water transfer window provides beneficial changes to designated critical habitat. Release of additional water for transfer from upstream sources has the potential to improve the flow volume in river channels feeding into the delta over the "no" transfer conditions. Increased flows can create conditions that reduce travel times for downstream migrants which improves migration success through reduced mortality. Furthermore, additional flow can increase the proportion of the river channels that are riverine in nature, compared to those which have tidal oscillations which can reverse flows in the river channels. Recent studies (Perry et al. 2018) have shown that riverine reaches have higher survival potential than tidal reaches. Thus, by increasing the proportion of river reaches with riverine characteristics in the Delta, survival potential is enhanced for emigrating spring-run Chinook salmon juveniles.

In summary, implementation of the PA is expected to place CV spring-run Chinook salmon critical habitat at risk of further degradation with factors such as warm water temperatures, low flows, and increased risk of entrainment into the central Delta through the DCC. Also, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, overall drier conditions (Lindley et al. 2007), and altered estuarine habitats through changes in hydrology and sea level rise.

Based on the analysis of available evidence, NMFS concludes that the PA is likely to appreciably diminish the value of critical habitat for the conservation of CV spring-run Chinook salmon (Table 2.8.4-2).

Table 2.8.4-2. Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on Designated Critical Habitat. Dark shading indicates selection. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Step	Apply the Available Evidence to Determine if	True/False	Action
	The proposed action is not likely to produce stressors that have direct or indirect adverse effects on the environment	True	End
A	Available Evidence: The PA will produce multiple stressors that will adversely affect the environment including but not limited to warm water temperatures in the Sacramento River and Clear Creek and increased water routing through the DCC.	False	Go to B
	Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect effects of	True	NLAA
В	Available Evidence: The PA will expose areas of designated critical habitat to multiple stressors, including but not limited to water temperatures warmer than life stage requirements in the Sacramento River and Clear Creek during spawning and egg incubation and increased entrainment into the central Delta through the DCC.	False	Go to C
	The quantity or quality of any physical or biological features of critical habitat or capacity of that habitat to develop those features over time are	True	NLAA
С	not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action  Available Evidence: The PA will reduce stressors that will reduce the quality of PBFs including, but not limited to water temperatures warmer than life stage requirements in the Sacramento River and Clear Creek during spawning and egg incubation and increased entrainment into the central Delta through the DCC.	False	Go to D
	Any reductions in the quantity or quality of one or more physical or biological features of critical habitat or capacity of that habitat to develop	True	NLAA
D	those features over time are not likely to reduce the value of critical habitat for the conservation of the species in the exposed area  Available Evidence: The PA will produce stressors that are likely to reduce the value of critical habitat for the conservation of the species in the exposed area, including but not limited to: sublethal and lethal water temperatures in the Sacramento River and Clear Creek during spawning and egg incubation and increased water routing through the DCC.	False	Go to E
Е		True	No D/AD MOD

Step	Apply the Available Evidence to Determine if	True/False	Action
	Any reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are not likely to appreciably diminish the overall value of critical habitat for the conservation of the species		
	The PA will produce stressors that are likely to diminish the overall value of critical habitat for the conservation of the species, including but not limited to sublethal and lethal water temperatures in the Sacramento River and Clear Creek during spawning and egg incubation and increased water routing through the DCC.	False	D/AD MOD

### 2.8.5 CCV Steelhead

Originally listed as threatened (63 FR 13347 1998); reaffirmed as threatened (71 FR 834 2006).

Detailed information regarding the federally listed DPS of CCV steelhead life history, status, and VSP parameters can be found in Section 2.2 Rangewide Status of the Species and Critical Habitat and Appendix B.

### 2.8.5.1 Status of the Species and Environmental Baseline

The status of the species, as well as the environmental baseline, have been described at length in Sections 2.2 and Appendix B, and Section 2.4, respectively. Critical to the integration and synthesis of effects are the VSP parameters of abundance, productivity, spatial structure, and diversity, which are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of jeopardy (50 CFR 402.02 2007) and are used as surrogates for "reproduction, numbers, or distribution." These VSP parameters have been used in status reviews for CCV steelhead performed by NMFS; the most recent of which was completed in 2016 (National Marine Fisheries Service 2016b). Status trends for CCV steelhead from that review are summarized in Table 2.8.5-1, and the VSP parameters specific to CCV steelhead may be estimated from the status trends. These VSP parameters are used to establish the reference condition of the population in the status of the species and environmental baseline and are used as the basis against which the risk to the populations and the risk to the DPS are assessed.

Table 2.8.5-1. Adapted from Table 5.6 in (Williams et al. 2016). Viability metrics for CCV steelhead populations. Total population size (N) is estimated as the sum of estimated run sizes from 2013 to 2016. The mean population size (S) is the average of the estimated run sizes from 2013 to 2016. Population growth rate (or decline; 10-year trend) is estimated from the slope of log-transformed estimated run sizes. The catastrophic metric (Recent Decline) is the largest year-to-year decline in total population size (N) over the most recent 10 years of available data.

Steelhead population	N	ŝ	10-yr trend (95% CI)	Recent decline (%)
American River ^a	472	157.3	-0.062 (-0.164, 0.039)	45.8
Clear Creek ^a	761	253.7	0.111 (-0.021, 0.244)	9.5
Coleman National Fish Hatchery	8461	2820.3	0.051 (-0.043, 0.146)	18.4
Feather River Fish Hatchery ^b	4119	1373.0	0.061 (-0.171, 0.292)	38.3

^a - American River and Clear Creek steelhead data are derived from redd counts. Some redds may be from non-anadromous *O. mykiss* or steelhead.

### 2.8.5.1.1 CCV Steelhead Abundance

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock et al. (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 from 1967 to 1977, to an average of approximately 2,000 through the early 1990s.

Population trend data remain extremely limited for the CCV steelhead DPS. The total populations on Battle Creek, Coleman NFH, and Feather River Fish Hatchery have significantly increased since the 2010 assessment (Williams et al. 2011) with all three populations showing positive population growth estimates over the last decade (Williams et al. 2016), Table 2.8.5-1). CCV steelhead returns to Coleman NFH have increased over the last four years. After a low of only 790 adults in 2010, the two years prior to the 2016 status review averaged 2,895 adults. The estimate of the total population of CCV steelhead returning to the Coleman NFH is 8,461 fish with an annual average run size of 2,820 fish (National Marine Fisheries Service 2016b). Since 2003, adults returning to the hatchery have been classified as natural (unclipped) or hatchery produced (adipose fin clipped). Natural adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically

^b - Feather River Fish Hatchery numbers include repeat spawners (fish returning the hatchery multiple times in a single year). These findings based on recent tagging studies suggest hatchery return numbers are likely slightly inflated.

200-300 fish each year. Starting in 2005, at NMFS' request, only natural steelhead were allowed to pass upstream of the fish weir at the Coleman NFH into the Battle Creek restoration area. From 2012 to 2014, the total population of natural-origin adults greater than 17 inches (size threshold identified for anadromous *O. mykiss* at Coleman NFH) passing the weir was 510 with an average run size of 170 adults (Williams et al. 2016). The low natural-origin CCV steelhead abundance places it in the moderate extinction risk category, albeit with lower hatchery influence than the 2010 assessment (Williams et al. 2011).

The returns of CCV steelhead to the Feather River Fish Hatchery were very low in 2009 and 2010, with only 312 and 86 fish returning in those years (National Marine Fisheries Service 2016b). Since then the numbers have rebounded, with a high of 1,797 in 2013, and have averaged over 1,100 fish from 2011 to 2016. Escapement at this hatchery seems to be quite variable over the years, despite the fact that stocking levels have remained fairly constant and that the vast majority of returning fish to the hatchery are of hatchery origin. In addition, recent tagging studies have shown that there are fish that re-enter the hatchery multiple times in a single season, which may slightly inflate the estimates of adult escapement back to the hatchery (National Marine Fisheries Service 2016b).

In the Mokelumne River, East Bay Municipal Utilities District (EBMUD) has included CCV steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (National Marine Fisheries Service 2016b). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000-2010). However, according to Satterthwaite et al. (2010), it is likely that a large majority of the *O. mykiss* spawning in the Mokelumne River are non-anadromous (or resident) fish rather than CCV steelhead. Video recordings of CCV steelhead moving through the fish ladder at Woodbridge Dam indicate that 92 percent–96 percent of adult steelhead observed were hatchery steelhead, with only 3–10 natural origin CCV steelhead returning to the Mokelumne River each year from 2010–2013. The Mokelumne River CCV steelhead population is highly supplemented by Mokelumne River Hatchery production, and this tributary's CCV steelhead population is considered to have a high risk of extinction based on low numbers and high hatchery influence.

Within the American River, redd counts have shown a decline of approximately 6 percent a year over the past decade. Over the period from 2002-2015, the annual average redd count on the American River was 142 redds per year. However, in 2015, only 58 redds were observed, which is the lowest number ever observed for this particular survey. The estimated total population for the American River is 472 fish, based on the redd counts, with an annual run size of 157 fish.

In Clear Creek, CCV steelhead the annual redd index has ranged from 43 to 409, with an average of 195 from 2003-2017. Preliminary estimates of adult return from the video monitoring station at the mouth of Clear Creek have been 75 to 215, with an average of 145 from 2014 to 2018. USFWS biologists have indicated that adipose fin clipped CCV steelhead are rarely observed during surveys on Clear Creek (National Marine Fisheries Service 2016b).

Escapement data for CCV steelhead in the San Joaquin River basin is spotty. However recent efforts to install weirs with video recording capability have allowed estimates of annual adult escapement to basin tributaries. The numbers of natural origin adult CCV steelhead remains low, with a high hatchery influence, placing the populations in the San Joaquin tributaries forming the Southern Sierra Nevada diversity group at a high risk of extinction. The annual number of adult steelhead counted moving upstream through the Stanislaus River weir ranged from 1-17 during

2005 to 2008 and 8-32 during 2011 to 2014 (Williams et al. 2016). Thirteen to fifty percent of those fish were identified as hatchery fish having clipped adipose fins, placing the Stanislaus River population at a high risk of extinction based on low numbers and high hatchery influence from outside the San Joaquin River basin. The nearest CCV steelhead hatchery to the Stanislaus River is the Mokelumne River Fish Hatchery.

### 2.8.5.1.2 CCV Steelhead Productivity

Limited information on CCV steelhead productivity in the Central Valley is available from incidental catch records in monitoring programs primarily focused on other fish species (e.g., Chinook salmon). In the late 1990s an estimated 100,000 to 300,000 naturally-produced juvenile steelhead left the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). Nobriga and Cadrett (2001) used adipose fin-clipped (hatchery) to unclipped (natural) CCV steelhead smolt catch ratios in the Chipps Island trawl and salvage to estimate that about 400,000 to 700,000 steelhead smolts were produced naturally each year from 1998 through 2000 in the Central Valley. These smolts are predominantly originating from the Sacramento River basin. The Mossdale trawls, on the San Joaquin River conducted annually by CDFW and USFWS, capture CCV steelhead smolts only in very small numbers. Those Mossdale recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. Generating quantitative steelhead production values from trawl surveys is challenging given the higher potential for juvenile steelhead to evade capture in trawls compared to target species (e.g., Chinook salmon).

Catches of CCV steelhead at the federal and state fish salvage facilities in the southern Delta are another source of information on the productivity of the CCV steelhead DPS, as well as the productivity of natural CCV steelhead relative to hatchery CCV steelhead (ftp.delta.dfg.ca.gov/salvage). Salvage of natural CCV steelhead has declined dramatically since the late 1990s, with an overall average of 1,324 smolts salvaged per year from 1998 to 2017 (Figure 2.8.5-1). The percentage of natural (unclipped) fish in salvage has fluctuated, but has leveled off to an average of 35 percent since a high of 95 percent in 1999.

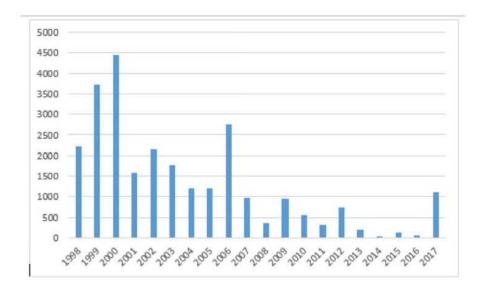


Figure 2.8.5-1. Unclipped (wild) annual juvenile CCV steelhead salvage from Brood Years 1998-2017 (adapted from Table 2.5.5-46 from the Delta Effects section).

### 2.8.5.1.3 CCV Steelhead Spatial Structure

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout; however, they are presently not considered part of the DPS. CCV steelhead are well-distributed throughout the Central Valley below the major rim dams (Good et al. 2005, National Marine Fisheries Service 2016b). Most of the CCV steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adults intercepted at the Coleman NFH weir), the American River, Feather River, and Mokelumne River.

The Recovery Plan (National Marine Fisheries Service 2014b) criteria for delisting CCV steelhead include a spatial structure very similar to that of CV spring-run Chinook salmon, with one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the northern Sierra Nevada diversity group, and two viable populations in the southern Sierra Nevada diversity group. It is clear that further efforts will need to involve more than restoration of currently accessible watersheds to make the DPS viable. The NMFS Recovery Plan calls for reestablishing populations into historical habitats currently blocked by large dams (National Marine Fisheries Service 2014b) and identifies several RPA actions (see Table 5-1. California and Central Valley Recovery Actions in Recovery Plan) from the NMFS 2009 Opinion that are expected to improve the spatial structure for CCV steelhead:

- RPA Action I.1.2: Channel Maintenance Flows
- RPA Action I.1.3: Spawning Gravel Augmentation
- RPA Action I.1.5: Thermal Stress Reduction
- RPA Action I.1.6 (Adaptively Manage to Habitat Suitability/IFIM Study Results)
- RPA Action I.7: Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass (Improve Yolo Bypass Adult Fish Passage)
- RPA Action I.6.1: Restoration of Floodplain Rearing Habitat (Increase Juvenile Salmonid Access to Yolo Bypass, and Increase Duration and Frequency of Yolo Bypass Floodplain Inundation)
- RPA Action I.2.6: Restore Battle Creek for Winter-Run, Spring-Run, and CCV Steelhead (Complete Battle Creek Salmon and Steelhead Restoration Project)

### 2.8.5.1.4 CCV Steelhead Diversity

CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006). Evidence of these declines are supported by genetic analysis, where the mean ratio of the number of alleles to the range in allele size, calculated from a population sample of microsatellite loci, decreases when a population is reduced in size (Nielson et al. 2003). Overall genetic diversity between Central Valley populations has also been shown to be relatively low. Garza et

al. (2008) analyzed the genetic relationships among CCV steelhead populations and found that fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers. The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, placing the natural population at a high risk of extinction (Lindley et al. 2007). Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms. Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams as summer-run have been extirpated (McEwan and Jackson 1996, Moyle 2002).

### 2.8.5.1.5 CCV Steelhead DPS Viability Summary

All indications are that natural origin CCV steelhead abundance, and the proportion of natural origin CCV steelhead in the DPS, have continued to decrease over the past 25 years with the long-term trend remaining negative (Good et al. 2005, National Marine Fisheries Service 2016b). Hatchery production and returns are dominant over natural origin CCV steelhead, with hatchery releases (100 percent adipose fin-clipped fish since 1998) remaining relatively constant over the past decade, but the proportion of adipose fin-clipped hatchery smolts to unclipped naturally-produced smolts has steadily increased over the past decade.

Using data through 2005, Lindley et al. (2007) found that data were insufficient to determine the status of any of the naturally-spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas. And although the widespread distribution of natural origin CCV steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes, most natural origin CCV steelhead populations are very small and may lack the resiliency to persist for protracted periods if subjected to additional stressors. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery origin CCV steelhead relative to natural origin fish. The most recent status review of CCV steelhead DPS (National Marine Fisheries Service 2016b) found the status of the DPS remains threatened.

Reclamation established a "without-action" scenario as part of the BA's Environmental Baseline to isolate and define potential effects of the proposed action apart from effects of non-proposed action. NMFS considers the without-action scenario to represent effects related to the existence of CVP and SWP facilities. The without-action scenario provides context for how these facilities have shaped the habitat conditions for species and critical habitat in the action area. Under Reclamation's "without action" scenario, there would be both positive and negative effects on the status of CCV steelhead. Higher flows in winter and spring could have both positive and negative effects on salmonids. Benefits of higher flows include lower water temperatures, increased dissolved oxygen, increased habitat complexity, more rearing habitat, more refuge habitat, increased availability of prey, less predation risk, less entrainment risk, lower potential for pathogens and disease, lower concentrations of toxic contaminants, and emigration cues. Reduced flows during dry fall months would have negative impacts on spawning adults, eggs, and alevin, and on rearing juvenile salmonids, resulting in increased temperature-dependent mortality of eggs, reduced juveniles growth rate and higher mortality of the juveniles, and a reduced population abundance.

However, as discussed previously, the Environmental Baseline also includes the effects of past and current operations of the CVP and SWP, and the additional effects of habitat restoration, predation from invasives, water quality, and other effects on species from Federal, State, and private actions to inform the current condition of CCV steelhead. As discussed above, the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years.

### **Summary of Proposed Action Effects on the Species**

Proposed action-related effects to CCV steelhead are summarized in Table 2.8.5-2. Detailed descriptions regarding the exposure, response, and risk of CCV steelhead to these stressors by division are presented in section 2.5. Major impacts of the PA to CCV steelhead include unsuitable water temperatures in summer rearing habitats (Clear Creek, middle Sacramento River, American River, and Stanislaus River), increased exposure into degraded south Delta habitats, and entrainment into south Delta facilities.

Additionally, the SRS Contractors Recovery Program will result in benefits to spawning success and production associated with increasing the quantity and quality of spawning substrate in the upper Sacramento River; benefits to rearing and migrating juvenile fish associated with the installation of fish screens and the construction of side-channel and in-channel habitat structures; and benefits to adult migrants and rearing and migrating juvenile fish from the construction of fish passage projects. The magnitude impact of these actions is medium to high based on past performance of the SRS Contractors Recovery Plan since 2000. The SRS commitment to the scope, mission and objectives of the Sacramento River Science Partnership is expected to improve the science that is used to protect and support the recovery of CCV steelhead.

Table 2.8.5-2. Summary of proposed action-related effects on CCV steelhead

_											
d life						turbidity and		wide.	River		
Increase						increase		creek-	Natural		
survival			of years)			cues, and		/holding:	Loss of	pulse flows	Creek)
d .			(30-60%		medium	create migration		migrating	Conditions;	maintenance	(Clear
Improve	Medium	Medium	Medium	Medium	Beneficial-	Pulse flows	Jan-April	Adults	Flow	Channel	Trinity
						rearing habitat.					
						additional					
						access to			/Barriers		
						temporary			тпреатнения		
						temporari			Impediments		
						Provide			Passage		
diversity.						turbidity.			Function;		
history						increasing			and		
d life						temperatures,			Morphology		
	pulse flows.					decreasing water			Kıver		
	during					passage by			Natural		
	шоусшеш					downsucam			, LUSS 01		
7	movement					downstream			· I nee of		
	juvenile					improve		wide	temperatures		
growth.	data shows		1			cues and		creek-	Water	pulse flows	Creek)
	Monitoring		(annually)		medium	create migration		/smolts:	Conditions;	attraction	(Clear
Increase	Medium:	Medium	High	Medium	Beneficial:	Increased flows	May-Jun	Juveniles	Flow	Spring	Trinity
						hyporheic flow.					
						reduced					
						dewatering and					
						de circon or					
						to effects of					
						will be exposed					
						Eggs and alevins					
						dewater redds.					
	changes.					period ends, will					
	flow					management					
	following					temperature					
success.	80					fall water					
tive	dewaterin					and/or after the					
reproduc	rates of					year types,		wide			
and	reports on					Critical water		creek-		tlows	Creek)
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	TAT III				IV LIIGI	Icadedons III		alcyllis.	Comminons	пынсан разс	Cicar
Survival	MIH				lethal	reductions in		alevine.	Conditions	instream base	(Clear
Reduced	Medium	Medium	WO.I	Medium	Sub-lethal to	Base flow	Dec-Mar	F.ggs/	Flow	Minimum	Trinity
Fitness				Exposed		THE COLUMN					
<b>.</b>			0.0000	3 .		Effect	,	3 °			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio		0	
е	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
TUDDADI	0	0									

						mortality.					
						predation, and					
						disease and					
						susceptibility to					
						and					
						reduced growth,					
survival.						stress and		wide		summer	
Reduced						>60° F cause		creek-		management:	Creek)
growth.						temperatures	35	/smolts	Temperature	temperature	(Clear
Reduced	Low	Low	Medium	Medium	Minor	Suboptimal	Jul-Aug	Juveniles	Water	Water	Trinity
						spawn mortality.					
						increased pre-					
						iccultury, and					
						fecundity and					
						to reduced					
						disease, leading					
						susceptibility to					
						and					
						F increase stress		ce point			
success.						timing, and >65°		complian			
nve						migration		am or		Tall	
reproduc						//O F delay		downside		Smithet and	
reproduc						>70° E delay		downstra		summer and	Ciock)
and						temperatures		holding:		management:	(Teek)
survival		TO THE PERSON NAMED IN COLUMN TO THE	100000000000000000000000000000000000000	COLONIA DI PINA PINA		water	(	migrating	Temperature	temperature	(Clear
Reduced	Medium	Low	Low	Small	Minor	Suboptimal	Aug-Oct	Adults/	Water	Water	Trinity
diversity.									Function		
history						migratory cues.			and		
life						does not provide			Morphology		
Reduced						refugia, and			River		
survival.						habitat and		wide	Natural		
Reduced						access to rearing		creek-	Loss of	flows	Creek)
growth.			(annually)			regime restricts	round	/smolts:	conditions;	instream base	(Clear
Reduced	Low	Medium	High	Medium	Minor	Static flow	Year	Juveniles	Flow	Minimum	Trinity
3											
diversity.									Function		
history									and		
Fitness				Exposed		THE TREATMENT PROPERTY.					
Ħ.			8	=		Effect	(3)	n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio		1941	
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	Magnitud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor	Action	DIVISION
יון יון	J. TT-I-IX	Manufacil	1	n	S	Y	7 16.	.J. A.	Dimana	4 44 44	1

Reduced survival probabili ty	Medium: Supported by a limited number of scientific and technical publicatio ns specific to the region and species. Quantitati ve results month-to- month channel inundation	High	Low (20% of years)	Large	Lethal	Decreased month to month flows resulting in decreased floodplain inundation and a temporary loss of spawning habitat leading to steelhead redds being dewatered.	January - June (January - February )	(Upper mid-Sacramen to River)	Spawning Habitat Availability, Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function	Minimum flows	Upper Sacramento /Shasta Division
Reduced survival probabili ty	Medium: Supported by select technical publicatio ns specific to the region and species. Quantitati ve results include average spawning flows to proposed minimum flows.	High	Low (20% of years)	Medium (33% - 42% of redds potentially dewatered )	Lethal	habitat.  Decreased month to month flows resulting in possible dewatering and stranding as decreased floodplain inundation and side-channel habitat isolated by reduced flows.	August - Decembe r (October Novemb er)	Migratin g, Spawnin g Adults (Upper Sacramen to River)	Spawning Habitat Availability, Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function	Fall and Winter Refill and Redd Maintenance	Upper Sacramento /Shasta Division
Probabl e Change in Fitness	Weight of Evidence	Magnitud e of Effect	Frequenc y of Exposure	Proportio n of Populatio n Exposed	Severity of Stressor/Lev el of Benefit	Individual Response and Rationale of Effect access to rearing	Life Stage (Timing)	Life Stage (Locatio n)	Stressor	Action Component	Division

Increase d survival probabili ty	High: Supported by multiple scientific and technical publicatio ns that include quantitativ e models specific to	Medium	Low	Medium	Beneficial: Low	Drought and Dry Year Actions have been identified for winter-run Chinook salmon as a way to mitigate for temperatures higher than 53.5°F which result in reduced egg survival.	January - July (May 15 - July)	Juveniles (Keswick Dam - RBDD)	Water Temperature	Drought and Dry Year Actions	Upper Sacramento /Shasta Division
Increase d survival probabili ty (NMFS/CDFW reduced fish screenin g criteria 5% loss)	Low: (Program matic action componen t) very little informatio n available as to how this action componen t would be implement ed (construction) or its effects when operated.	High, uncertain	High (Permane nt)	Uncertain	Beneficial: High	Framework level action component. Programmatic action component. Construction activities are not described but operation is assumed to comply with NMFS and CDFW fish screening guidance.	April - October (Uncertai n)	Juveniles (Middle Sacramen to River)	Operation of new or repaired fish screens on water diversions. Entrainment/ Impingemen t at water diversions,	Small Screen Program (Spawning/rea ring habitat restoration)	Upper Sacramento /Shasta Division
Probabl e Change in Fitness	Weight of Evidence  (U.S. Fish and Wildlife Service 2006)	Magnitud e of Effect	Frequenc y of Exposure	Proportio n of Populatio n Exposed	Severity of Stressor/Lev el of Benefit	Individual Response and Rationale of Effect	Life Stage (Timing)	Life Stage (Locatio n)	Stressor	Action Component	Division

Division	Action	Stressor	Life	Life	Individual	Severity of	Proportio	Frequenc	Magnitud	Weight of	Probabl
	Component		Stage (Locatio	Stage (Timing)	Response and Rationale of	Stressor/Lev el of Benefit	n of Populatio	y of Exposure	e of Effect	Evidence	e Change
			n)	9	Effect		<b>3</b>	61			i B.
37					These actions		Exposed			the region	Fitness
					are expected to					and	
					benefit steelhead					species.	
					that spawn in						
					the Sacramento						
					River as well,						
					but to a lesser						
I Inner	Drafting of	Water	Inveniles	Iannary -	I Ising	Reneficial:	Medium	High	Medium	High:	Increase
Sacramento	Temperature	Temperature	(Keswick	July	conservative	Low		ğ		Supported	d
/Shasta	Management		Dam -	(May 15	forecasts to	i				by	survival
Division	Plan Using		RBDD)	- July)	inform the					multiple	probabili
	Forecasts				the Temperature					and	3
					Management					technical	
					Plan is expected					publicatio	
					to reduce the					ns that	
					frequency of					include	
					there being					quantitativ	
					temperatures					e models	
					higher than					specific to	
					53.5°F during					the region	
					Chinook salmon					species.	
					spawning and						
					incubation						
					period. It is						
					provide an						
					indirect benefit						
					to the other						
					species,						
					including						
					spawn in the						
					Sacramento						
					River as well.						

	allaly Sis.										
	analysis										
	WUA								Function		
	include								and		
	ve results								Morphology		
	Quantitati								River		
	species.								Natural		
	region and								Loss of		
	to the								Cover,		
	arrande en								шэнсаш		
	ne enecific					COMMISSION			Instraam		
	publicatio					conditions.			Habitat and		
	technical					spawning		,	Riparian		
	and					improved	_	to River)	Loss of		
	scientific					providing	February	Sacramen	Conditions,		
g success						at lower nows	GI -	miq-	Flow		DIVISION
open min						capacity (WOA)	(Decemb	(opper	гранаонну,	TIOWS	/Sliasia
snawnin	_					canacity (WIIA)	Decemb	(I Inner	Availability	flowe	Shacta
d	Supported		of years)		medium	habitat carrying	r - April	g Adults,	Habitat	Minimum	Sacramento
Increase	High:	Medium	Low (20%	Large	Beneficial:	Increased	Decembe	Spawnin	Spawning	Winter	Upper
	species.										
	and										
	the region										
	specific to										
	TOT.				_						
	not										
	however										
	ns,					Juveniles.					
	publicatio					rearing					
	technical					death among					
ţ						depletion, or					
probabili	scientific					bioenergetic					
SULVIVAL				(4,19<		stress, disease,	- July)	KBDD)			Division
rate and			of years)	days		can lead to	(May 15	Dam -		Pool Mgmt.)	/Shasta
growth	pported		(45 - 68%	(12% of		excess of 61°F	July	(Keswick	Temperature	Cold Water	Sacramento
Reduced	100	Medium	Medium	Medium	Sub-lethal	Temperatures in	January -	Juveniles	Water	Tier 1 (Shasta	Upper
Fitness	H			Exposed							
5				=		Effect		n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
LIODADI	_	Mingere	Freducing	rioporuo	Severity of	Individual	Lile	ТПе	Stressor	Action	DIVISION
Probabl		Magnifud	Leannone	Dranartia	Covarity of	Individual	1 :60	1 :60	Cimacon	Antion	

Reduced reproduc tive success	Medium: Supported by multiple scientific and technical publicatio ns, however not specific to the region and	Low	Low (5 - 7% of years)	Medium (15% of days >68°F)	Sub-lethal	Temperatures higher than 68°F would cause increased disease and decreased swimming performance in adults, and increased disease, impaired smoltification, reduced growth, and increased	August - Decembe r (August - October)	Migratin g Adults (Keswick Dam - RBDD)	Water Temperature	Tier 4 (Shasta Cold Water Pool Mgmt.)	Upper Sacramento /Shasta Division
Reduced growth rate	Medium: Supported by multiple scientific and technical publicatio ns, however not specific to the region and	Low	Low (5 - 7% of years)	Medium (59% of days >61°F)	Sub-lethal	Temperatures in excess of 61°F can lead to stress, disease, bioenergetic depletion, or death among rearing Juveniles.	January - July (May 15 - July)	Juveniles (Keswick Dam - RBDD)	Water Temperature	Tier 4 (Shasta Cold Water Pool Mgmt.)	Upper Sacramento /Shasta Division
Fitness	however not specific to the region and species.	ыест	Exposure	Exposed	el of Benefit	Effect  increased disease, impaired smoltification, reduced growth, and increased predation for late emigrating juveniles.	(11ming)	n) (Locatio			
Probabl e	Weight of Evidence	Magnitud e of	Frequenc y of	Proportio n of	Severity of Stressor/Lev	Individual Response and	Life Stage	Life Stage	Stressor	Action Component	Division

d survival probabili ty	Low	Low	Low	Low	Subjethal	Temperatures in excess of 61°F can lead to stress, disease, bioenergetic depletion, or death among rearing Juveniles.	January - July (May 15 - July)	Juveniles (Keswick Dam - RBDD)	Water Temperature	Delta Smelt Summer-Fall Habitat	Upper Sacramento /Shasta Division
Reduced survival probabili ty	Low: (Program matic action componen t) very little informatio n available as to how this action componen t would be implement ed (constructi on).	Low	Low: (Uncertain	Low	Sub-lethal	Framework programmatic action component. Construction activities are not described but assumed construction effects related to installation of fish screens include: changes in flow, stranding (installation of coffer dams), and handling.	July - Decembe r (Uncertai n), April - October (Uncertai n)	Adults, Juveniles (Middle Sacramen to River)	Construction or installation of fish screens on water diversions. Passage Impediments / Barriers, Flow Conditions, Loss of Riparian Habitat and Instream Cover	Small Screen Program (Spawning/rea ring habitat restoration)	Upper Sacramento /Shasta Division
Probabl e Change in Fitness	Weight of Evidence	Magnitud e of Effect	Frequenc y of Exposure	Proportio n of Populatio n Exposed	Severity of Stressor/Lev el of Benefit	Individual Response and Rationale of Effect  predation for late emigrating juveniles.	Life Stage (Timing)	Life Stage (Locatio n)	Stressor	Action Component	Division

Division	Action	Stressor	Life	Life	Individual	Severity of	Proportio	Frequenc	Magnitud	Weight of	Probabl
	Component	700000000000000000000000000000000000000	Stage	Stage	Response and	Stressor/Lev	n of	y of	e of	Evidence	e
			(Locatio	(Timing)	Rationale of	el of Benefit	Populatio	Exposure	Effect		Change
			<u>n</u>	,	Effect		= .	8)			5
							Exposed				Fitness
Upper	Juvenile Trap	Monitoring,	Juveniles	January -	Uncertain.	Sub-Lethal	Uncertain	Low (5 -	Low	Low:	Decrease
Sacramento	and Haul (tier	Maintenance	(Upper	July	Programmatic			7% of		(Program	d growth
/Shasta	4 intervention)	, Research	Sacramen	(Uncertai	action			years)		matic	rate,
Division		Studies, etc.	to River)	n)	component.					action	Decrease
		(minimizatio			Increased stress					componen	Р
		n for Water			and mortality					t) very	survival
		Temperature			related to					little	probabili
		s)			capture and					informatio	ţ
					handling.					n	
					Minimization					available	
					measure					as to how	
					intended to					this action	
					increase relative					componen	
					survival of					t would be	
					Juvenile winter-					implement	
					run during Tier					ed or as to	
					4 water					its effects.	
					temperature						
					operations.						
					Depending on						
					timing and						
					location of trap						
					and haul						
					operations,						
					juvenile						
					steelhead could						
					be collected and						
					returned to the						
					river or						
					relocated.						

	when										
	CIICUS										
	effects										
	ed or its										
	implement										
	t would be					guidance.					
	componen					screening			diversions		
	this action					CDFW fish			t at water		
	as to how					NMFS and			Impingemen		
	available					comply with			Entrainment/		
	р :					assumed to			diversions.		
3	THE PERSON NAMED OF					operation	::0		Hatel		
₹ .	informatio					oneration is			water		
probabili	little					component,	October)	to River)	screens on	pool mgmt.)	Division
survival	) very		nt)			action	(June -	Sacramen	repaired fish	(Cold water	/Shasta
р	(uncertain		(Permane		Low	programmatic	October	(Middle	new or	Slough intakes	Sacramento
Increase	Low:	Low	High	Small	Beneficial:	Framework	April -	Juveniles	Operation of	Wilkins	Upper
						species					
						effects to					
						mini potentiai					
						limit nation					
						The state of the s					
						minimization			Cover		
						and			Instream		
	on).					include BMPs			Habitat and		
	(constructi					window and			Riparian		
	ed					water work			Loss of		
	implement					appropriate in-			Conditions,		
	t would be					during an			Flow		
	componen					would occur			/ Barriers,		
	this action					that construction	*		Impediments		
	as to how					NMFS assumes	October)		Passage		
	available					described.	(June -		diversions.		
	n					activities are not	October		water		
Ţ	informatio					construction	April -	to River)	screens on		
probabili	little					component,	October)	Sacramen	of fish	pool mgmt.)	Division
survival	) very		ion)			action	r (July -	(Middle	installation	(Cold water	/Shasta
d	(uncertain		(Construct			programmatic	Decembe	Juveniles	OI	Slough intakes	Sacramento
Decrease	Low:	Low	Uncertain	Small	Sub-lethal	Framework	July -	Adults,	Construction	Wilkins	Upper
Fitness				Exposed							
j,				= .		Effect	ą	3			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio		•	
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Propagi		0									

Increase d growth rate	Low: (Program matic action componen t) very little informatio n available as to how or where this action componen t would be implement ed or the extent of its effects.	Low	High (Permane nt)	Uncertain	Beneficial: Low	Increased habitat quality and quantity. Framework programmatic action component, no description of timing, location or extent of effects.	July - Decembe r (Uncertai n), April - October (Uncertai n)	Adults, Juveniles (Middle Sacramen to River)	Riparian vegetation, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Side-Channel habitat (Spawning/rea ring habitat restoration)	Upper Sacramento /Shasta Division
Increase d reproductive success, Increase d survival probability	Low: (Program matic action componen t) very little informatio n available as to how this action componen t would be implement ed or as to its effects.	Low	Low (tier 4 years = 5 - 7% of all years)	Small (Interventi on measure may not apply to steelhead)	Beneficial: Low	Uncertain. Programmatic action component. Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of adult salmonids entrained in water diversions (e.g. Yolo and Sutter Bypasses).	July - Decembe r (Uncertai n)	Adults (Middle Sacramen to River)	Passage Impediments / Barriers, Entrainment/ Impingemen t at water diversions	Adult rescue (tier 4 intervention)	Upper Sacramento /Shasta Division
Probabl e Change in Fitness	Weight of Evidence	Magnitud e of Effect	Frequenc y of Exposure	Proportio n of Populatio n Exposed	Severity of Stressor/Lev el of Benefit	Individual Response and Rationale of Effect	Life Stage (Timing)	Life Stage (Locatio n)	Stressor	Action Component	Division

	effects.					Maintenance (2.5.2.3.4.1)					
	ed or its					Refill and Redd					
	implement					and Winter			Function		
	t would be					component Fall			and		
	componen					affecting action			Morphology		
	this action					fall flows			River		
	as to how					more reliable			of Natural		
	available			J		may provide	er)	to River)	Cover, Loss		
	n			dewatered		coordination	Novemb	Sacramen	Instream		
success	informatio			potentially		Proposed	•	(Upper	Habitat and		
tive	little			redds		component.	(October	g Adults	Riparian		Division
reproduc	) very	J		42% of	(Uncertain)	action	ı	Spawnin	Loss of	(fall ops.)	/Shasta
	(uncertain	(Uncertain		(33% -	Low	programmatic	Decembe	ĝο	Conditions,	smoothing	Sacramento
Increase	Low:	Low	Low	Medium	Beneficial:	Framework	August -	Migratin	Flow	Rice Decomp	Upper
	its effects.										
	extent of										
	ed or the										
	implement										
	t would be										
	componen						n)				
	this action						(Uncertai				
	or where						October				
	as to how					effects.	April -		Alteration		
	available					or extent of	apply),		Habitat		
success	n					timing, location	don't		Physical		
tive	informatio					description of	windows		Cover,		
reproduc	little					component, no	work		Instream	3	
lifetime	t) very					action	in-water		Habitat and	restoration)	
В	componen					programmatic	n, typical	to River)	Riparian	ring habitat	
Increase	action					Framework	(Uncertai	Sacramen	Loss of	(Spawning/rea	Division
rate,	matic		nt)			and quantity.	٦	(Middle	Availability,	Injection	/Shasta
d growth	(Program		(Permane		Low	habitat quality	Decembe	Juveniles	Habitat	Gravel	Sacramento
Increase	Low:	Low	High	Uncertain	Beneficial:	Increased	July -	Adults,	Spawning	Spawning	Upper
Fitness				Exposed							
B.				=		Effect		n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	Magnitud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor	Action	Division
											1

2						Opinions				ğ	
in the baseline)						NMFS/USFWS Biological				(Cold water pool mgmt.)	/Shasta Division
None (included	NA	NA	NA	NA	NA	Covered under 2005	NA	NA	NA	Battle Creek Restoration	Upper Sacramento
						releases.					
						volume of					
						timing and					
						change in the					
						there be any					
						criteria nor will					
						management					
						meeting					
						frequency of					
						change in the					
						there will be no					
						raise such that					
						a Shasta Dam					
						me inclusion of					
						operations with					
						change in					DIVISION
						committed to no				Kaise	/Snasta
						Keciamanon nas				Snasta Dam	Sacramento
None	NA	NA	NA	NA	NA	None.	NA	NA	NA	Operation of a	Upper
	effects.										
	ed or its					effect.					
	implement					raise. Unknown					
	t would be					Shasta Dam					
	componen					type/extent of					
	this action					dependent on					
	as to how					existing TCD					
	available					ations to					
	n					changes/modific					
	informatio					Unknown					
	little					component.				pool mgmt.)	Division
	) very					action				(Cold water	/Shasta
	(uncertain					programmatic			Temperature	improvements	Sacramento
None	Low:	NA	NA	NA	NA	Framework	NA	NA	Water	Shasta TCD	Upper
Fitness				Exposed							
ņ			6	=		Effect	5575	n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	Magnitud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor .	Acuon	TOTOTO I

Reduced growth; Reduced survival	medium	high	high	high	sublethal	Physiological effects - increased susceptibility to disease (e.g., anal vent inflammation) and predation. Visible symptoms of thermal stress in juvenile steelhead are associated with exposure to	Year-round	Juvenile rearing Primarily upstream of Watt Ave. area	Water temperatures warmer than life stage requirements , particularly occurring upstream of Watt Ave. during June through September	American River	American River
Reduced genetic integrity	high	high	high	small	sublethal	Reduced genetic diversity. Garza et al. (2008) showed that genetic samples from the population spawning in the river and the hatchery population were "extremely similar".	Late- Dec early Apr.	Spawnin g Primarily upstream of Watt Ave. area	Nimbus Hatchery – hatchery O. mykiss spawning with natural- origin steelhead	American River	American River
Reduced survival, reduced reproduc tive success	high	high	medium	small	lethal	Redd dewatering and isolation prohibiting successful completion of spawning	Late- Dec early Apr	Spawnin g Primarily upstream of Watt Ave. area	Folsom/Nim bus releases – flow fluctuations	American River	American River
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Spring Mgmt. of Spawning Locations	Upper Sacramento /Shasta Division
Probabl e Change in Fitness	Weight of Evidence	Magnitud e of Effect	Frequenc y of Exposure	Proportio n of Populatio n Exposed	Severity of Stressor/Lev el of Benefit	Individual Response and Rationale of Effect	Life Stage (Timing)	Life Stage (Locatio n)	Stressor	Action Component	Division

	Division
	Action Component
	Stressor
	Life Stage (Locatio n)
	Life Stage (Timing)
were warmer than 65°F at Watt Avenue for 57 percent of days and warmer than 68°F for 20 percent of days (Table 2.5.4-2 in section 2.5.4 American River Division). Modeled long-term average water temperatures at Watt Avenue from June through September under the proposed Project (including 2025 climate change simulation) range from	Individual Response and Rationale of Effect  daily mean water temperatures above 65°F (Water Forum 2005a). From August through September in years 1999 through 2018, daily mean water temperatures
	Severity of Stressor/Lev el of Benefit
	Proportio n of Populatio n Exposed
	Frequenc y of Exposure
	Magnitud e of Effect
	Weight of Evidence
	Probabl e Change in Fitness

Reduced survival	low	medium	medium	small	lethal	Fry stranding and juvenile isolation; low flows limiting the availability of quality rearing habitat including predator refuge habitat	Year- round	Juvenile rearing Primarily upstream of Watt Ave. area	Folsom/Nim bus releases – flow fluctuations; low flows, particularly during late summer and early fall	American River	American River
Reduced survival	high	medium	medium	small	lethal	Redd dewatering and isolation.	Late- Dec May	Embryo incubatio n Primarily upstream of Watt Ave. area	Folsom/Nim bus releases – flow fluctuations	American River	American River
Reduced survival	high	medium	high	small	sublethal and lethal	Sub-lethal effects - reduced early life stage viability; direct mortality; restriction of life history diversity (i.e., directional selection against eggs deposited in Mar. and Apr.)	Late-Dec - May	Embryo incubatio n Primarily upstream of Watt Ave. area	Water temperatures warmer than life stage requirements , particularly occurring upstream of Watt Ave. in April and May	American River	American River
						approximately 66°F to 70°F (ROC LTO BA).					
Probabl e Change in Fitness	Weight of Evidence	Magnitud e of Effect	Frequenc y of Exposure	Proportio n of Populatio n Exposed	Severity of Stressor/Lev el of Benefit	Individual Response and Rationale of Effect	Life Stage (Timing)	Life Stage (Locatio n)	Stressor	Action Component	Division

	Delta	American River	Division
operations	DCC gate	American River  DCC Gate operations	Action Component
times	Transit	Water temperatures warmer than life stage requirements , particularly occurring downstream of Watt Ave. during March through June Routing	Stressor
Sacramen	Juveniles	Smolt emigratio n Througho ut entire river  Juveniles - Sacramen to River-Delta	Life Stage (Locatio n)
migratio n and	Juvenile	Jan Jun.  Jun.  June  Juvenile  migratio  n and  rearing –  Nov –  June	Life Stage (Timing)
mortality due to increased	Increased	Physiological effects – reduced ability to successfully complete the smoltification process, increased susceptibility to predation  increased mortality due to routing into the delta interior with lower survival rates	Individual Response and Rationale of Effect
lethal	sublethal to	sublethal – sublethal – lethal	Severity of Stressor/Lev el of Benefit
gates open from Oct	medium -	medium - gates open from Oct 1 through Nov 30, typically closed Dec 1 through Jan 31. Closed Feb 1 through May 20. Estimated 25% to 50% of juvenile SH population emigrates by the end of January.	Proportion of Population
gates infrequent	low. DCC	low. DCC gates infrequent ly operated in December and January	Frequenc y of Exposure
3	High	High	Magnitud e of Effect
to High - There are	Medium	high  High - There are a number of publicatio ns regarding the relative survival in various North Delta and Central Delta migratory routes; conclusio ns supported by modelling results.	Weight of Evidence
survival; lesser	Reduced	Reduced growth; Reduced survival Reduced survival; lesser effect in final PA due to revised DCC operation s in Decembe r-January	Probabl e Change in Fitness

Ĭ,	Delta DCC gate operations H
mics downstream to River - of DCC location	Delta Delta  Altered Hydrodyna  Local To River - Delta  Juveniles
eniles Juvenile migratio ramen n and tiver - rearing - lta Nov - June	
mortality when gates are open due to changes in routing or transit time through interactions with	
lethal	
opening of gates reduces the proportion of riverine reaches	1 through Nov 30, typically closed Dec 1 through Jan 31. Closed Feb 1 through May 20. Estimated 25% to 50% of juvenile SH population emigrates by the end of January.
ing.	ly operated in December and January
ngin	
There are a number of publicatio ns regarding the	a number of publications regarding the relative survival of Chinook salmon in various North Delta and Central Delta migratory routes but not steelhead; routing and transit time conclusions supported by modelling results.
reduced fitness and/or survival when gates are open; lesser	effect in final PA due to revised DCC operation s in Decembe r-January

Division	Action	Stressor	Life	Life	Individual	Severity of	Proportio	Frequenc	Magnifud	Weight of	Prohabi
	Component	100000000000000000000000000000000000000	Stage	Stage	Response and	Stressor/Lev	n of	y of .	e of	Evidence	e
			(Locatio	(Timing)	Rationale of	el of Benefit	Populatio	Exposure	Effect		Change
			n)		Effect		n .				E.
			80				Exposed				Fitness
					influence		DCC			of	due to
					downstream of		location,			Chinook	revised
					DCC location		closing of			salmon,	DCC
					and gate		gates			but not	operation
					operations		extends			steelhead	s in
							the			in various	Decembe
							riverine			North	r-January
							reaches			Delta and	8
							farther			Central	
							downstrea			Delta	
							m. All fish			migratory	
							emigratin			routes;	
							g in Oct			hydrodyna	
							and Nov			mic	
							have the			conclusio	
							potential			ns	
							to			supported	
							encounter			by	
							open			modelling	
							gates, fish			and	
							emigratin			physical	
							gin			testing	
							drought			results.	
							year may				
							encounter				
							up to 10				
							days in				
							Dec and				
							January				
							with gate				
							in open				
							position				

r-January											
Decembe											
s in											
operation											
DCC											
revised	steelhead										
due to	apply to			Nov - Jan.		concerns					
final PA	Should			closures		water quality					
effect in	open.			for		operations for					
lesser	when			Potential		closed. Gate					
success;	the DCC			migrating.		when gates are					
90	through			adults are		migratory delays					
spawnin	Chinook			fall while		followed by					
of	of			and into		opened,					
reduction	straying			summer		when gates are					
possible	related to		annually	over		River system	May				
n,	studies		and closed	opened		Mokelumne	n July-				
migratio	tagging		opened	gates		straying into the	migratio	Delta		operations	
Delayed	medium -	Medium	High-	High -	Minor	Increased	Adult	Adults -	Routing	DCC Gate	Delta
	not certain										
	method is										
	ess of this										
	effectiven										
	long term										
	process,										
	salvage										
	the										
	impacts in					Facility	1				
	predation					Collection	April				
	looked at					Tracy Fish	Oct -	Delta			
	have					channel at the	rearing -	to River -			
survival	studies					secondary	n and	Sacramen			
d	several				High	predators from	migratio		injections	Improvements	
Increase	Medium -	high	high	medium	Beneficial:	Removal of	Juvenile	Juveniles	CO2	CVP	Delta
Fitness				Exposed							
Đ,				п		Effect		n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	Magnitud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor	Action	DIVISION
			1				*	4.6	2	4-41	7

	the										
	through										
	survival										
	as well as										
	predation,					COIIIEXI DEIOM					
S.						Population					
threshold	-	population		steelnead)		2.8.3.2.3					
4-1-11				1		30636					
loss	of the	of		baisn		facilities. See					
revised	efficiency	proportion		for SJR		at salvage					
due to	the	on small		to large		fish population	June				
final PA	evaluated	exposure		), medium		Delta Juvenile	NOV -		racilities		
епести		печислеу		population		1-o bercent of	Learning -		Delia export		
Part in		framework		nomilation		1-8 nament of	regring		Delta evnort	1757 F#1275 527.0	
lesser		high		CCV		approximately	n and		the south	Exports	
survival;	Numerous	sustained		(overall	lethal	from	migratio	- Delta	and loss at	South Delta	
reduced	High -	Medium -	high	small	Sublethal to	Loss ranges	Juvenile	Juveniles	Entrainment	CVP/SWP	Delta
						contaminants.					
						allu					
						and					
						water quality					
	certain.					predators, poor					
	Delta less					exposure to					
	in south					transit time and					
S	migrations					Delays increase					
threshold	salmonid					migratory cues.					
loss	mics on					appropriate					
revised	hydrodyna					LOSS OI					
due to	ETIECTS OF					uic souul Della.					
dine to	Effects of					the south Delta					
final PA	hallad					in channels of					
effect in						hydrodynamics					
lesser	studied					altered	June				
likely	mics well					in response to	Nov -	Delta	routing		
growth;	hydrodyna					migratory delays	rearing -	to River -	Delta/		
reduced	effects of		exports			condition due to	n and	Sacramen	ics in south	Exports	
survival,	to High -		continual		lethal	decreases in	migratio	, '	nydrodynam	South Delta	
Reduced	Medium	Medium	High-	Medium -	Subjethal to	Mortality or	Juvenile	Juveniles	Altered	CVP/SWP	Della
Fitness	L			Exposed			-	-		Carrie Carrie	
1 5						Епест		n)			
· Cuange	v. 2	T. I.	Amender	- opunio	or or memoria	TOTAL OLINIO	(	The state of			
Change		Effect	Fynosure	Populatio	el of Renefit	Rationale of	(Timino)	(Locatio			
e		e of	v of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	Magnitud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor	Action	Division

	the couth	horriore in									
	through	to the				conditions while					
	ппс	exposure				Marrier Marer					
	timo	person,				withour motor	,,,				
	transit	neriod.				exposure to	<u>.</u> ;				
	increase	migratory				increased	populatio				
	barriers	adult SH				mortality due to	SJ River				
	that the	during				increased	Delta -				
	indicated	occurs				potential for	(south				
	have	barriers				times with	January				
	studies	n of		population		increased transit	n - July -			Barriers	
survival	several	ınstallatıo		SJ River	lethal	migration and	migratio	Delta		Agricultural	
Reduced	Medium -	Medium -	high	Low- only	Sublethal to	Delayed	Adult	Adults -	transit times	South Delta	Delta
	records.										
	salvage										
	ed by										
	document										
	is well										
	channels	SH.									
	Delta	population									
	south	SJK basın									
	шшс	mgii ioi									
	spring-run	bigh for									
	I iming of	basin SH									
	TISKS.	Sacrament									
	predation	for									
	IIICIE986	io oe row									
	Dena and	to be low									
	Delta and	ownerted									
	the south	harriers is									
	through	to the				Production					
	time	exposure				predators					
	fransit	neriod				exposure to					
	increase	migratory				increased					
	barriers	Steelhead				mortality due to	7				
	that the	during				increased	June				
	indicated	occurs				potential for	Nov -	Delta			
	have	barriers		population		times with	rearing -	to River -			
	studies	n of		SJR		increased transit	n and	Sacramen		Barriers	
survival	several	ınstallatıo		ıncludes	lethal	migration and	migratio	1		Agricultural	
Reduced	Medium -	Medium -	high	medium -	Sublethal to	Delayed	Juvenile	Juveniles	transit times	South Delta	Delta
Fitness				Exposed							
						PHOL		w)			
in		Ellect	Exposure	n opulatio	CI OI DEHEIR	Effort	(Smmr)	Locatio			
Chanco	T. Tuchica	Effort	Fynosuro	Donulatio	ol of Bonofit	Dationals of	Timing	d ocatio		Component	
e	Evidence	e of	v of .	n of .	Stressor/Lev	Resnonse and	Stage	Stage		Component	
Probabl	ALCINITION OF	TATASTITUTA		1							

Division Ac		Delta CY ex	Delta Do
Action Component		CVP/SWP exports	DCC gate operations
Stressor		Shift in Operations	Increased entrainment and loss at the South Delta Exports facilities
Stage (Locatio n)		Juveniles - Sacramen to River - Delta	Juveniles - Sacramen to River - Delta
Life Stage (Timing)		Juvenile migratio n and rearing - Oct - April	Juvenile migratio n and rearing - Nov - June
Individual Response and Rationale of Effect	moving upriver over barriers	Shift in exports to CVP from SWP to reduce impacts of predation from the CCF when capacity at CVP exists	Increased mortality of entrained fish at the CVP and SWP fish salvage facilities
Severity of Stressor/Lev el of Benefit		Beneficial: High	Sublethal to lethal
Proportion of Population		small	Small to medium
Frequenc y of Exposure		medium	High
Magnitud e of Effect	expected to be high for SJR basin population SH.	medium	Low - sustained population effects on a small to medium proportion of the
Weight of Evidence	Delta and increase predation risks. Timing of spring-run in the south Delta channels is well document ed by salvage records	Medium- Several studies show lower losses at the CVP for salvaged fish – availabilit y of capacity at the CVP is	High - numerous studies have evaluated the potential
Probabl e Change in Fitness		Increase d survival	Reduced survival; lesser effect in final PA due to revised DCC

	Delta	Delta  Delta	Delta
	North Bay Aqueduct		
	ment men men	tting tting rainment rainment ingemen to fish ens	tting trainment ingemen to fish ens
	iles nen	nen er - liles	iles iles er -
•	Juvenile In migratio M n and bv	ii e g - ii e	atio
Mortality caused by entrainment			sed tity due to y into the els of the Slough Slough
	Minor	Minor	Minor
Sillan	Cmall	small Small	Small
exports occur on	high -	high	high -
screens are	on hydrodyna mics	low - very small proportion of population will be present in Barker Slough, low impacts of diversion volumes on hydrodyna mics	population present in the Delta low - very small proportion of population will be present in Barker Slough, low impacts of diversion volumes on hydrodyna mics
High - monitorin g has few	screens in monitorin g efforts.	medium - few salmonids observed in regional monitorin g efforts in the past. No fish observed behind screens in monitorin g efforts.	salmonids entering the Delta interior and becoming vulnerable to entrainme nt at the fish salvage facilities medium- few salmonids observed in regional monitorin g efforts in the past. No fish observed behind screens in monitorin g efforts.
minimal change in fitness		reduced survival	operatoin s and revised loss threshold s.

	and have										
	screens,										
	the										
	in front of										
	observed										
	are										
	some rish					elevated					
	however					likely to be					
	acrocus,					predation to					
	screens	and make				predation is					
16	the	and intake				Slough where					
¥ (1)	through	screens	15			channel of Rock					
predation	entrained	the fish	every year			routing into the					
increased	tish are	vicinity of	occurs			mortality due to					
n or	that no	be in the	diversion			increased	June				
Grand	The same	Times to	i. Sugar			Potomini ioi	1 101	Com			
mioratio	indicate	likely to	Slough			notential for	Nov -	Delta			
delay in	g reports	of fish are	the Rock			times with	rearing -	to River -			
due to	monitorin	numbers	through			increased transit	n and	Sacramen		diversions	
fitness	annual	small	pumping		lethal	migration and	migratio			Slough water	
reduced	Medium -	low -	high -	Small	sublethal to	Delayed	Juvenile	Juveniles	routing	CCWD Rock	Delta
		cleaning				removal					
		during	JУ			during weed	June		cleaning		
		screens	infrequent			grapping nooks	Nov-	Delta	Weed		
	available	area or	removed			capture by	rearing -	Dala Viver -	aquatic		
III TIUICSS	arribble	or of	woods			unpurgement,	II dilu	Division	Smith		
in fitness	chidies	to be in	made			impingament	n ond	Cocromon	during	. refusemen	
change	reports or	unlikely	Aquatic	N. O'CHOS ARCHA	lethal	due to	migratio		t/ canture	Aqueduct	
minimal	low. No	low - fish	low.	Small	sublethal to	Injury or death	Juvenile	Juveniles	Impingemen	North Bay	Delta
		cleaning									
		during				onto fish screens	June				
		screens	ly			impingement	Nov -	Delta			
	available	area of	infrequent			dredge or	rearing -	to River -	cleaning		
in fitness	studies	to be in	removed			entrainment into	n and	Sacramen	sediment		
change	reports or	unlikely	Sediment		lethal	due to	migratio	1	during	Aqueduct	
minimal	low. No	low - fish	low.	Small	sublethal to	Injury or death	Juvenile	Juveniles	Entrainment	North Bay	Delta
	screens										
	fish										
	barrier	location									
	of positive	screen									
	efficiency	present at				intake.					
	regarding	to be				Pumping Plant					
Fitness				Exposed							40
5						Епест		n)			
Change		Епес	Exposure	Populatio	et of Benefit	Kationale of	(gamarr)	(Locatio			
Channe	PAINCHE	Fife	you	Donal atta	of af Bonefit	Deticable of	Timina	orage.		Component	
	Evidence	o of	v of	n of	Strossor/I ov	Dosnonso and	Stage	Stage	50103901	Component	Division
Prohabl	Weight of	Magnitud	Francisco	Proportio	Severity of	Individual	I ifa	I ifa	Strossor	Action	Division

	TCITIONAL					CHamici					
	CO2 in					secondary	Apin				
	effectiven					during predator	Oct -	Delta			
	studies					mortality due to	n and rearing -	Sacramen to River -		H	
Reduced	Medium – several	low	high	small	Sub-lethal to lethal	Small increase in morbidity and	Juvenile migratio	Juveniles -	CO2 Injections	CVP Improvements	Delta
	methods.										
	on sampling										
	literature			steelhead)							
	studies,			baisn							
	removal	study		for SJR		sampling gear					
	predator	years of		to large		trapment in	June				
	previous	to three		), medium		entanglement/en	Nov -	Delta			
	from	over two		population		predation due to	rearing -	to River -	(	THE STATE OF THE S	
	reports	sampling		CCV		injury and	n and	Sacramen	gear	studies	
survival	Several	infrequent		(overall	lethal	vulnerability to	migratio	1	sampling	removal	
reduced	Medium -	Low -	low	small	Sublethal to	Increased	Juvenile	Juveniles	capture in	Predator	Delta
	sampling methods.										
	on										
	literature										
	studies.	study				Samping gear					
	predator	years or				campling gear					
	previous	to three				entanglemenven					
	пош	OWI IMO				mortality due to	Iviay				
	reports	sampling				injury and	n July -		gear	studies	
survival	Several	infrequent			lethal	vulnerability to	migratio	Delta	sampling	removal	
reduced	Medium -	Low -	low	Small	Sublethal to	Increased	Adult	Adults -	capture in	Predator	Delta
	g.										
	monitorin										
	historical										
	OUSELVED										
	been										
Fitness				Exposed							
₽,			0	=		Effect		n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio		9	
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	1
Probabl	Weight of	DUTTER	Frequenc	11000110	CONCLUS OF	*****			200001	1	-

Delta	Delta	Division
Water Transfers	Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Action Component
low flows	Temporary change in water flow/water quality (20 days Oct- May, 60 days June- Sept)	Stressor
Adults - Delta	Adults and juveniles may migrate through the area on their way to spawning grounds or as outmigrat ing juveniles.	Life Stage (Locatio n)
Adult migratio n July - May	Adult migratio n (July – May) and juvenile emigrati on (Nov – June).	Life Stage (Timing)
Elevated river flows may reduce straying by providing stronger homing cues to adult steelhead migrants in the lower reaches of the Delta	During the annual 70 to 80 days of periodic operation, individual adult steelhead may be delayed in their spawning migration from a few hours to several days. Juveniles may be delayed on their downstream movements by closed gates for several hours while gates are closed on flood tides.	Individual Response and Rationale of Effect
Beneficial: low	minor	Severity of Stressor/Lev el of Benefit
Large	low	Proportio n of Populatio n Exposed
low	Low	Frequenc y of Exposure
low	low	Magnitud e of Effect
low. No reports or studies available	predators and sensitivity of smaller fish to CO2 exposure Low-data on steelhead migration and rearing in Suisun Marsh is low	Weight of Evidence
increased fitness	minimal	Probabl e Change in Fitness

Delta Sacramento Deep Water Ship Channel Food Study Food Study Channel Channel Channel Channel	Delta Fall Delta Temporary Adults - Smelt Habitat change in Operations flow/water quality  Adults - Quality	Delta Water Transit Juveniles Transfers times - Sacramen to River - Delta
Adult migratio n (July – May) and juvenile emigrati on (Nov – June).	Adult upstream migratio n (July – May)	Juvenile migratio n and rearing - Nov - June
and false and false and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River into Deepwater ship channel when boat locks are open, exposure to reduced water quality in Port of Sacramento and Deepwater ship channel, increased	Potential changes in Delta hydrodynamics due to export reductions and increased Delta inflow from upstream may create better flow attractions for upstream migrations of adult steelhead	Elevated river flows may reduce transit times through riverine reaches of the Delta
Lethal to	Minor benefit	Beneficial: low
low	high	Small
low	Medium (Septembe r and October of above normal and wet water year types)	low
low	Low – adult steelhead already migrate upstream during this period	low
Low – little informatio n on steelhead migration behavior and use within the Sacrament o Deepwate r ship channel, and Port of Sacrament o	Low – little informatio n available on adult migration cues in the Delta	low. No reports or studies available
fitness	Minimal benefit	increased fitness

						indirect stress effects, smaller			forming flows		
Version Control of the Control of th						to predation; poor energetics;		s to Mossdale	reduction in channel		
Reduced					predation	growth rates; starvation; loss		ce of Stanislau	complexity due to		
growth rates;		to High			lethal via	suppressed		Confluen	rearing habitat		Kiver
Reduced	Medium	Medium	High	Medium	Sublethal and	Reduced food	Dec-May	Juvenile	Reduction in	PA Conditions	San Joaquin
						emigration;					
						size at time of					
						effects, smaller					
						indirect stress					
						poor energetics;		Mossdale			
						to predation;		s to	habitat		
survival						starvation; loss		Stanislau	rearing		
Reduced					predation	growth rates;		ce of	inundate		
rates;					lethal via	suppressed		Confluen	flow to		
growth		to High	2		indirectly	supply;		rearing	overbank		River
Reduced	Medium	Medium	High	Medium	Sublethal and	Reduced food	Dec-May	Juvenile	Lack of	PA Conditions	San Joaquin
	project)										
	v of										
	complexit		design)								
	given		on project	0							
	by 2030		depending	design)							
- 61	completed		1	on project							
	will be		completed	depending							
	likelihood		once				n (				
	Low (for	<u> </u>	exposure	completed			migratio				
growth	habitat);	completed	of	once			for			Habitat	
	floodplain	project	frequency	exposure			Feb-June	migration		Joaquin River	
survival,	effects of	e once	medium	medium	7000		rearing;	and	The state of the s	Lower San	8 0 0 0 0 0 0 0 0
ď	beneficial	(applicabl	(likely	(likely	High		for	rearing	Habitat	Measure -	River
Increase	High (for	High	Medium	Medium	Beneficial:	C	Dec-May	Juvenile	Floodplain	Conservation	San Joaquin
						juvenile fish					
						predation for					
						poaching,					
						angling and					
						exposure to					
Fitness				Exposed				ı,			
<b>5</b>				T		Effect	9	2 1			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio		Post	
	Evidence	e of	vof	n of	Stressor/Lev	Resnonse and	Stage	Stage	501 63901	Component	DIVISION
Prohahl	Weight of	Magnifud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor	Action	Division

timing						thermal stress;		s to	in May and		
tion						and in Delta;		Stanislau	, primarily		
outmiora						river reaches		ce of	requirements		
diversity						rise at lower		Confluen	life history		
Reduced						river before		migration	warmer than		
survival;			c			leave reach of	Jun	out-	temperatures		River
Reduced	Medium	Medium	High	Medium	Sublethal	Fish do not	Feb –	Juvenile	Water	PA Conditions	San Joaquin
						of predation					
						and higher risk					
						residence time					
						increased					
						leading to					
						through Delta					
						misdirection		Mossdale			
tımıng						thermal stress;		s to			
поп						and in Dena,		Stanislau			
Outmigra						HVCI ICACHES		50.01			
outmiors						river reaches		CP Of			
<b>∃</b> `						rise at lower		Confluen			
diversity					predation	temperatures					
Reduced		3			lethal via	river before		migration			
survival;		to High			indirectly	leave reach of	Jun	out-	flow		River
Reduced	Medium	Medium	High	Medium	Sublethal and	Fish do not	Feb -	Juvenile	Suboptimal	PA Conditions	San Joaquin
									March-May		
						growm,		INTOSOURIE	requirements		
						errects, poor		Mossdala	stage		
SULVIVAL						monect suess		nerginer	шешьюту		
Keduced					bregation	in direct strass		Stanislan.	Warmer man		
Dadings,					redation	to prodution:		Commuci	comportation		
rates:	20.50	20.00			lethal via	starvation: loss		Confluen	temperatures		10.70
orowth	to High	to High	111000000000000000000000000000000000000	12.000.000.000.000.000.00	indirectly	stress:	Something strategy &	mioration	water		River
Reduced	Medium	Medium	Medium	Medium	Sublethal and	Metabolic	Dec-May	Juvenile	Springtime	PA Conditions	San Joaquin
						emigration;					
						size at time of					
Fitness				Exposed							
Ħ.			1	=		Effect		n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
1100001	9	g					)	1			

						thormal strass:					
						and in Delta;					
						TIVEL TEACHES					
						river reaches		o Activo			
					*-020100310900000	rise at lower		s River		SACAMETER COMMUNICATION	
diversity					predation	temperatures		Stanislau		Release Plan	
Reduced		8695			lethal via	river before		B	- June)	Stepped	
survival;		to High	2000		indirectly	leave reach of	Jun.	emigratio	flow (March	operations and	Division
Reduced	Medium	Medium	High	Medium	Sublethal and	Fish do not	Jan. –	Smolt	Suboptimal	Seasonal	East Side
								Bridge			
								Blossom			
								Orange			
								Dam to			
								Goodwin	requirements		
				eggs)				, e	stage		
				70% of				emergenc	life history	Release Plan	
				2% and		deformities		n and	warmer than	Stepped	
survival		ş		(between	Lethal	Embryonic		incubatio	temperatures	operations and	Division
Reduced	Medium	High	Medium	Medium	Sublethal and	Egg mortality,	Dec-June	Egg	Water	Seasonal	East Side
						growth rates					
						run; suppressed		Bridge			
						steelhead or fall-		Blossom			
						other CCV		Orange	flow		
						activities of		Dam to	overbank		
				275074.20		by nest-building		Goodwin	from lack of		
				eggs)		from smothering		e	resulting		
				70% of		egg mortality		emergenc	gravel	Release Plan	
				2% and		interstitial flow;		n and	spawning	Stepped	
survival				(between		from lack of		incubatio	fines in	operations and	Division
Reduced	Medium	High	High	Medium	Lethal	Egg mortality	Dec-June	Egg	Excessive	Seasonal	East Side
Fitness				Exposed		De l'include de de de l'include					
Ħ.			8	=		Effect	2007	<u> </u>			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	Magnitud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor	Action	DIVISION
			1						20	12. 27	

reproduc tive success						individual:		Orange	resulting		
						habitat; For		Dam to	gravel	Release Plan	
	Minimara	MEMINIM	THE	Mediani	Subjectial	suitable	Dec-1-eo	g	fines in	operations and	Division
	Madium	Madium	Hi-h	Madium	Cablathal	Dodrood	er Esh	Charmin	Evaccina	Casconal	East Cida
							July- Septemb		(*		
						grown,	acute	pringe	requirements		
						effects, poor	likely	Blossom	life history		
survival						indirect stress	ure stress	Orange	warmer than		
Reduced					predation	to predation;	temperat	Dam to	temperatures	Release Plan	
rates;	1	3			lethal via	starvation; loss	with	Goodwin	water	Stepped	
growth	to High	to High			indirectly	stress;	round,	rearing	summer	operations and	Division
Reduced	Medium	Medium	Medium	Medium	Sublethal and	Metabolic	Year	Juvenile	End of	Seasonal	East Side
						emigration;					
						cize at time of			TIOWS		
						effects smaller			flows		
						poor energencs,		aguita	forming		
						to predation;		Biossom	reduction in		
SULVIVAL						starvation; loss		Orange	due to		
Reduced					predation	growth rates;		Dam to	complexity	Release Plan	
rates;					lethal via	suppressed		Goodwin	habitat	Stepped	
growth		to High			indirectly	supply;	round	rearing	rearing	operations and	Division
Reduced	Medium	Medium	High	Medium	Sublethal and	Reduced food	Year	Juvenile	Reduction in	Seasonal	East Side
				-		emigration;					
						size at time of					
						effects, smaller					
						indirect stress		,			
						poor energetics;		Bridge			
						to predation;		Blossom	habitat		
survival						starvation; loss		Orange	rearing		
Reduced					predation	growth rates;		Dam to	inundate	Release Plan	
rates;		3			lethal via	suppressed		Goodwin	flow to	Stepped	
		to High			indirectly	supply;	round	rearing	overbank	operations and	Division
	Medium	Medium	High	Medium	Sublethal and	Reduced food	Year	Juvenile	Lack of	Seasonal	East Side
Fitness				Exposed							) i
<b>E</b> ,			9	= ,		Effect	ļ	n)			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio		0.75	
220.471	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
of Probabl	Weight of	Magnitud	Frequenc	Proportio	Severity of	Individual	Life	Life	Stressor	Action	Division

East Side  Division  Alteration of  Stanislaus  River  Dissolved  Oxygen  Requirement -  (7.0 mg/L) 31  miles  upstream to	East Side Seasonal Water Division operations and Stepped Warmer than Release Plan stage requirements (Mar - June)	East Side Conservation Spawning Division Measure – Habitat Spawning and Habitat Restoration	overbank flow	Division Action Stressor Component
y Juvenile steelhead upstream of OBB in summer	Smoltific ation and emigratio n n Stanislau s River at mouth	Adult spawning	Blossom Bridge	Life Stage (Locatio n)
Juvenile steelhead present upstream of action area	Jan Jun.	Dec-Feb		Life Stage (Timing)
Juvenile steelhead are primarily present upstream of OBB, however, few may be migrating through during summer months, and may be expossed to	Missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress;	Increased suitable spawning habitat;	cost to attempt to "clean" excess fine material from spawning site	Individual Response and Rationale of Effect
Minor	Sublethal	Beneficial: medium		Severity of Stressor/Lev el of Benefit
Small	Medium	Medium		Proportio n of Populatio n Exposed
Low	Low (while June temps are unsuitable for smoltificat ion in 70% of years, very few steelhead likely smolt at that time)	High (Once completed , habitat will be available each year)		Frequenc y of Exposure
Low	Low	Medium		Magnitud e of Effect
Medium	Medium	High		Weight of Evidence
Low	Reduced diversity.	Increase d reproduc tive success		Probabl e Change in Fitness

						significant					
						to have a					
						is not expected					
						1-2 mg/L, which					
						approximately					
						of					
						and a difference					
						period of time,					
						for a short					
						This would be				Bridge (OBB)	
						reduced DO.				Blossom	
						exposed to				Orange	
						and may be				upstream to	
						summer months,				miles	
						through during				(7.0 mg/L) 31	
						migrating				Requirement -	
						few may be	area	summer		Oxygen	
						OBB, however,	of action	B.		Dissolved	
						upstream of	upstream	of OBB		River	
						present	present	upstream	Barrier	Stanislaus	
						are primarily	steelhead	steelhead	Low DO	Alteration of	Division
Low	Medium	Low	Low	Small	Minor	Adult steelhead	Adult	Adult	Temporary	2.5.7.1.3	East Side
						effect.					
						significant					
						to have a					
						is not expected					
						1-2 mg/L which					
						of					
						and a difference					
						period of time,					
						for a short					
						This would be				Bridge (OBB)	
						reduced DO.				Blossom	
Fitness				Exposed				8			
Đ,				n		Effect	20000	<u>n</u> )			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	Magnitud	riequenc	a robor ao	Contract of				The state of the s		

			criteria)								
			depending on design								
			flow,								
			vary with								
			likely to								
			but extent			emigration					
		of river)	each year,			size at time of					
		to length	available			predation; larger					
growth		compared	will be			refuge from				Restoration	
increased		restoration	, habitat			growth rates;				Habitat	
survival,		of	completed			increased				Spawning and	
d		to extent	(Once		low	supply;	round	rearing	Habitat	Measure -	Division
Increase	High	Low (due	Medium	Medium	Beneficial:	Increased food	Year	Juvenile	Rearing	Conservation	East Side
			year)			habitat.					
			every			alternate rearing				Restoration	
			gravel			displacement to			Habitat	Habitat	
1			place			disruption and		1	and Rearing	Spawning and	
growth			(goal is to			behavioral	round	rearing	of Spawning	Measure -	Division
Reduced	High	Low	High	Small	Minor	Short term	Year	Juvenile	Construction	Conservation	East Side
Fitness				Exposed							
ij			-	=		Effect	3	Ð,			
Change		Effect	Exposure	Populatio	el of Benefit	Rationale of	(Timing)	(Locatio			
e	Evidence	e of	y of	n of	Stressor/Lev	Response and	Stage	Stage		Component	
Probabl	Weight of	nitud		Proportio	Severity of	Individual	Life	Life	Stressor	Action	Division

### 2.8.5.2 Assess Risk to CCV Steelhead by Division and Associated Diversity Group

Population viability is determined by four parameters: abundance, productivity, spatial structure, and diversity. Both population spatial structure and diversity (behavioral and genetic) provide the foundation for populations to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability, diversity, and utilization of properly functioning conditions (habitats), as defined in McElhany et al. (2000), and the connections between such habitats. Thus, reductions in the quantity or quality of available habitat are assumed to reduce a population's spatial structure.

### 2.8.5.2.1 Northwestern California Diversity Group

### 2.8.5.2.1.1 Assess Risk to Clear Creek CCV Steelhead

As described in section 2.5, habitat conditions in Clear Creek, the Sacramento River, and the Delta are negatively affected by the PA in a number of ways. CCV steelhead originating from the Clear Creek watershed are exposed to altered river flows that diminish the long-term sustainability of the population. Releases of water to the Clear Creek stream channel below Whiskeytown Dam are generally insufficient to sustain natural riverine processes and functions. In addition, dam releases are often insufficient to maintain adequate water temperature and flows below the dam for the entire year. These stressors, coupled with the additional stressors identified for the main stem Sacramento River and Delta, reduces the population's current spatial structure (by reducing habitat quantity and quality), which, in turn, reduces the likelihood of recovery for the Clear Creek CCV steelhead population.

Adult CCV steelhead typically migrate into Clear Creek from late August through April. Spawning occurs from mid-December through April, with over 90 percent occurring by mid-February (Schraml et al. 2018). Redds are located from Whiskeytown to the confluence, with the highest proportion located downstream of river mile 6 (Schaefer et al. 2019). Early migrating adults and rearing juveniles located downstream of the compliance point at IGO may be exposed to unsuitable water temperature in the summer months. Exposure to stressful water temperatures during juvenile rearing is likely to reduce the spatial structure and factors that influence productivity (e.g., growth rate).

The diversity of Clear Creek steelhead also may be affected by the PA. Water releases from Whiskeytown Dam has changed the thermal regime and likely the food web structure of Clear Creek. While further research is still needed on the mechanisms driving residency and anadromy in *O. mykiss*, environmental conditions experienced in the early fresh water life stages (e.g., water temperature, flow) may influence frequency of anadromy (Kendall et al. 2014). Without knowing the role that resident *O. mykiss* play in population maintenance and persistence of anadromous *O. mykiss*, it is difficult to assess whether the current conditions on Clear Creek, which may favor residency, are detrimental to the anadromous population in Clear Creek or not (Lindley et al. 2007).

All of the above factors, which reduce the spatial structure, productivity and abundance of Clear Creek CCV steelhead, compromise the capacity for this population to respond and adapt to environmental changes. In addition to impacts to the spatial structure and productivity, the PA is

expected to result in direct mortality to CCV steelhead. PA-related sources of CCV steelhead mortality include: (1) entraining juveniles into the Central and South Delta (as described in detail in the supplemental Delta analysis in Section 2.5.5.11, revisions to DCC operations in the final PA somewhat reduce this effect relative to the original PA); (2) entraining and impinging juveniles at the pumps (both direct and indirect loss; as described in detail in the supplemental Delta analysis in Section 2.5.5.11, revisions to loss thresholds and commitments to review and technical assistance in the final PA provide some assurance that species risks will be conservatively managed and reduce this effect relative to the original PA); and (3) loss associated with the CHTR program. Future projections over the duration of the PA (*i.e.*, through 2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of the PA, further increasing the risk of the population.

### 2.8.5.2.2 Basalt and Porous Lava Diversity Group

### 2.8.5.2.2.1 Assess Risk to Mainstern Sacramento River CCV Steelhead

As described in Section 2.5 and summarized in Table 2.8.5-2, habitat conditions in the mainstem Sacramento River are negatively affected by the PA in a number of ways, including, but not limited to: (1) regulating flows in a way that impairs natural river processes; and (2) providing flows and water temperatures in the lower reaches Sacramento River spawning habitat that are stressful to CCV steelhead. These stressors, coupled with the additional stressors identified for the Delta, reduces the Sacramento River CCV steelhead population's current spatial structure by reducing habitat quantity and quality.

The diversity of mainstem Sacramento River CCV steelhead also may be affected by the PA. Water releases from Shasta Dam has changed the thermal regime and the food web structure of the Sacramento River (Lieberman et al. 2001) such that a resident life history strategy may have fitness advantages over anadromous forms (McEwan 2001, Lindley et al. 2006). Little is known about the relationship of resident and anadromous forms of O. mykiss. Without knowing the role that resident O. mykiss play in population maintenance and persistence of anadromous O. mykiss, it is difficult to assess whether the current conditions on the Sacramento River, which may favor residency, are detrimental to the anadromous population in the Sacramento River or not (Lindley et al. 2007). Zimmerman et al. (2008) did demonstrate that resident rainbow trout can produce anadromous smolts and anadromous steelhead can produce resident rainbow trout in the Central Valley. However, the study indicated that the proportion of resident rainbow trout to anadromous steelhead in the Central Valley is largely in favor of the resident form, and is even more prominent in the Sacramento River where about 92 percent (142 out of 154) of O. mykiss sampled were offspring of resident adults (Zimmerman et al. 2008). Only 1 out of the 154 O. mykiss sampled showed an anadromous migratory history, although the sampling was not intended to be selective for adults, so some fish sampled may not yet have made their downstream migration to the ocean.

Revisions to the Cold Water Pool Management section of the final PA include the addition of Section 4.10.1.3.3 Upper Sacramento Performance Metrics. The objective of these performance metrics is to ensure that the performance of the PA operations for temperature management falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of winter-run Chinook salmon temperature dependent mortality. This revision affects the steelhead analysis by increasing the certainty that

the analysis more accurately characterizes exposure and risk to steelhead due to the PA operations. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which is based on the central tendency to capture the most likely conditions – to be a more accurate characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management do not change quantitatively due to the revisions included in the final PA, as this commitment to assess cold water management does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

We do consider the PA components that are intended to offer as much protection as practicable in drought or extreme conditions, including the process for development of an annual temperature management plan, the use of conservative forecasts, protection of the third cohort of winter-run Chinook salmon after two consecutive years of poor survival, and specific "at the ready" actions for drought and dry years. The temperature management plan may reduce the likelihood of exceeding the temperature target, which is used in the characterization of exposure to increased temperatures in the analysis. The conservation measures intended to protect the third cohort of winter-run Chinook salmon after two consecutive years of poor survival may allow opportunities for actions to be implemented to reduce temperature-related effects on CCV steelhead despite the probability of year types that may occur. Finally, NMFS expects a reduction in extreme effects on the species throughout extended drought due to the Drought and Dry Year Actions. We note that potential benefit of a toolkit of actions to be taken in drought conditions, and the process by which early warnings of drought conditions may allow for clear and swift development of a drought contingency plan, but we also consider that managing a listed species in a crisis-management scenario is not a long-term strategy to avoiding extirpation.

All of the above factors, which reduce the spatial structure, diversity, and abundance of mainstem Sacramento River CCV steelhead, compromise the capacity for this population to respond and adapt to environmental changes. In addition to impacts to the spatial structure and possibly life history diversity, the PA is expected to result in direct mortality to CCV steelhead. PA-related sources of CCV steelhead mortality include: (1) redd dewatering in the upper Sacramento River; (2) entraining juveniles into the Central and South Delta (as described in detail in the supplemental Delta analysis in Section 2.5.5.11, revisions to DCC operations in the final PA somewhat reduce this effect relative to the original PA); (3) entraining and impinging juveniles at the pumps (both direct and indirect loss; as described in detail in the supplemental Delta analysis in Section 2.5.5.11, revisions to loss thresholds and commitments to review and technical assistance in the final PA provide some assurance that species risks will be conservatively managed and reduce this effect relative to the original PA); and (4) loss associated with the CHTR program. Future projections over the duration of the PA (*i.e.*, through 2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of the PA, further increasing the risk of the population.

### 2.8.5.2.3 Northern Sierra Nevada Diversity Group

### 2.8.5.2.3.1 Assess Risk to American River CCV Steelhead

As described above, habitat conditions in the lower American River are negatively affected by the PA to such a degree that the survival, growth, and reproductive success of multiple steelhead

life stages is reduced. For example, American River steelhead are exposed to stressful water temperatures during spawning, embryo incubation, juvenile rearing, and smolt emigration. Based on the entire effects analysis, it is apparent that the water temperatures and flows expected with implementation of the PA will continue to substantially limit the quantity and quality of habitat, thereby limiting the spatial structure of American River steelhead. These limitations to the spatial structure of a population which have already been blocked off from all of its historic spawning habitat certainly reduces the viability of American River steelhead.

The behavioral and genetic diversity of American River steelhead also is expected to be negatively affected by the PA. Warm water temperatures in the American River under the proposed PA are expected to result in higher fitness for steelhead spawned early (e.g., January) in the spawning season, as eggs spawned later (e.g., March) would be exposed to water temperatures above their thermal requirements (see Assess Species Response, Section 2.5, above). This selective pressure towards earlier spawning and incubation would truncate the temporal distribution of spawning, resulting in a decrease in population diversity.

The genetics of American River steelhead have been completely altered by Nimbus Fish Hatchery operations and the historical use of out of basin hatchery stocks. Nimbus Fish Hatchery Steelhead Program has been working to address these issues by examining the potential to replace the Nimbus Fish Hatchery steelhead broodstock with genetically appropriate sources, although a change in hatchery practices is uncertain. Release of juvenile hatchery steelhead inriver (Sunrise location) was also done experimentally in March 2019, and is expected to minimize straying of returning adults relative to Sacramento River release sites (Discovery Park location).

In addition to the negative effects on the spatial structure and diversity, the PA is expected to reduce the abundance of American River steelhead. Direct mortality (e.g., redd dewatering, water temperature-related egg mortality) associated with proposed operations has been documented at both the egg and juvenile life stages. The fitness consequences from water temperature-related effects on juveniles (e.g., compromised immune system, increased predation, reduced energy for growth) also would be expected to negatively affect the population growth rate.

The combined effects of the PA on the spawning, embryo incubation, juvenile rearing, and smolt emigration life stages of CCV steelhead in the American River, reduces the viability of the population and places the population, which was already at high risk of extinction (see Section 2.5 Status of American River Steelhead), at even greater risk. This notion is especially supported considering that Naiman and Turner (2000) demonstrated how even slight reductions in survival from one life stage to the next at each and every life stage can have serious consequences for the persistence of a population, and the PA reduces the survival of each CCV steelhead life stage, including the life stage transition from smolt to adult-sized fish in the ocean. Although the PA does not directly affect CCV steelhead in the ocean, it indirectly lowers their ocean survival because they are entering it in a weakened state.

Increased water demand is expected to result in considerable challenges to flow and water temperature management for American River aquatic resources below Nimbus Dam, and will likely exacerbate the adverse habitat conditions already occurring in the river under present day water demands. In addition to increasing water demands, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures,

increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley et al. 2007).

All of the above factors, which reduce the spatial structure, diversity, and abundance of American River CCV steelhead, compromise the capacity for this population to respond and adapt to environmental changes. In addition to impacts to the spatial structure and life history diversity, the PA is expected to result in direct mortality to CCV steelhead. PA-related sources of CCV steelhead mortality include: (1) redd dewatering; (2) entraining juveniles into the Central and South Delta (as described in detail in the supplemental Delta analysis in Section 2.5.5.11, revisions to DCC operations in the final PA somewhat reduce this effect relative to the original PA); (3) entraining and impinging juveniles at the pumps (both direct and indirect loss; as described in detail in the supplemental Delta analysis in Section 2.5.5.11, revisions to loss thresholds and commitments to review and technical assistance in the final PA provide some assurance that species risks will be conservatively managed and reduce this effect relative to the original PA); and (4) loss associated with the CHTR program. Future projections over the duration of the proposed PA (*i.e.*, through 2030), considering both increasing water demands and climate change, exacerbate risks associated with continuation of the PA, further increasing the risk of the population.

### 2.8.5.2.4 Southern Sierra Nevada Diversity Group

### 2.8.5.2.4.1 Assess Risk to Stanislaus River CCV Steelhead

Habitat conditions in the Stanislaus River and Delta are negatively affected by the PA to such a degree that the survival, growth, and/or reproductive success of all inland life stages of CCV steelhead is reduced (see Table 2.8.5-2). For example, Stanislaus River steelhead are exposed to stressful water temperatures during adult immigration, embryo incubation, juvenile rearing, and smolt emigration. In addition, flow-dependent habitat availability is limited, particularly for the spawning, juvenile rearing, and smolt emigration life stages. Based on the effects analysis throughout the CCV steelhead life cycle, it is apparent that the PA has substantial negative effects on the habitat, and therefore spatial structure, in the Stanislaus River and Delta. A further reduction to the spatial structure of a population which has already been blocked off from its historic spawning habitat certainly reduces the likelihood of recovery. Of equal importance to spatial structure in determining population viability is the presence of sufficient behavioral and genetic diversity within the population to allow it to be flexible and adapt to changing environmental conditions through utilization of a wide range of habitats.

The combined effects of the PA on the adult immigration, spawning, embryo incubation, juvenile rearing, and smolt emigration life stages of CCV steelhead in the Stanislaus River, reduces the viability of the population and places the population, which was already at high risk of extinction due to extremely low abundance, at even greater risk. As previously described, Naiman and Turner (2000) demonstrated how even slight reductions in survival from one life stage to the next at each and every life stage can have serious consequences for the persistence of a populations. Considering that the PA reduces the survival of each CCV steelhead life stage, including the life stage transition from smolt to adult-sized fish in the ocean, Stanislaus River steelhead may not persist with implementation of the PA.

In addition to the negative effects on the spatial structure and life history diversity, the PA is expected to reduce the abundance of Stanislaus River steelhead. Mortality associated with the PA in the Stanislaus River is expected through such sources as potential water temperature-related pre-spawn adult mortality, redd dewatering, and egg suffocation from deposition of fines.

Once a juvenile CCV steelhead has survived moving downstream through the Stanislaus River tributary, it still must overcome the stressors located in the Delta, which include barriers constructed across waterways to preserve water elevations for irrigation, lack of a Head of Old River barrier (HORB) that helps keep water flow and CCV steelhead in the mainstem of the San Joaquin River, altered regional hydrodynamics resulting from the diversion of large volumes of water by the CVP and SWP, and direct entrainment and salvage within the export facilities related to those export actions. As described in detail in the supplemental Delta analysis in Section 2.5.5.11, revisions to loss thresholds and commitments to review and technical assistance in the final PA provide some assurance that species risks will be conservatively managed and reduce the effects of altered regional hydrodynamics and direct entrainment and salvage relative to the original PA.

Results from Buchanan (2019) indicate overall mortality of juvenile CCV steelhead migrating from the San Joaquin River to Chipps Island range from 45 to 85 percent. Recent modelling (Buchanan 2019) of the effects of the HORB presence on the estimated CCV steelhead survival from the HOR to Chipps Island indicates that survival is higher when the barrier is installed, compared to when it is not installed. The predicted difference in survival that was attributable to the presence of the barrier was estimated to range from 0.13 for a Vernalis flow of 319 cfs to 0.19 for a Vernalis flow of 3,889 cfs. Although there is high uncertainty in the predicted survival estimates for both conditions of the barrier's presence, and moderate uncertainty for the predicted effect of the barrier on survival, the predicted survival effect of the barrier was positive for all values of Delta inflows at Vernalis. Buchanan (2019) cautions that this modelling is based on a limited data set (2011-2016). Based on NMFS's current understanding of survival probabilities based on barrier condition at the Head of Old River, in years when flow conditions would have allowed HORB installation, the PA will lead to lower survival of steelhead juveniles emigrating from the San Joaquin River basin by 13-19 percent for flows of up to 5,000 cfs at Vernalis. Based on this information, Reclamation's PA is expected to create conditions that would reduce steelhead survival to Chipps Island for Stanislaus River steelhead and the entire Southern Sierra Nevada Diversity Group, further exacerbating the already diminished status of this diversity group.

Future projections over the duration of the PA (*i.e.*, through 2030), considering both increasing water demands and climate change, exacerbate risks to Stanislaus River steelhead. For example, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased temperatures, increased frequency of drought, increased frequency of flood flows, and overall drier conditions (Lindley et al. 2007).

### 2.8.5.2.5 Population context

It is possible that some of the loss modeled to occur at the export facilities under the PA flow conditions might have occurred due to far-field effects in the south Delta under COS conditions, but no modeling tool is available that allows comparison of both direct loss and far-field effects under PA vs. COS conditions.

NMFS put the combined CCV steelhead loss in a population context (see full caveats in Section 2.5.5.8.3.1) by expressing the estimated annual combined loss as a percentage of the steelhead population in the Delta. These results should be considered a coarse screening level analysis due to limitations of the salvage-density method itself (limited historical time-frame of loss; relatively simple weighting of loss by export changes and no other operational factors) and use of the average annual modeled loss rates (over the 15-year data period) scaled to both low and high population estimates. Since it is likely that annual observed loss in a particular year is correlated with population size, use of the average loss rate likely overestimates the population effect in a low-population year, and underestimates the population effect in a high-population year. Additionally, the revised loss thresholds related to OMR management in the final PA are expected to limit loss during April and May to levels less than estimated using the Salvage Density Model results, and to levels comparable to loss observed under the COS.

Estimated annual combined loss from the COS is 6,560 juveniles, and estimated annual combined loss from the PA is 7,988. Good et al. (2005) estimated the CCV steelhead population at approximately 94,000-336,000 juveniles, and Nobriga and Cadrett (2001) estimated the CCV steelhead population at 413,069-658,453 juveniles. Applying the estimated annual combined loss to the lowest and highest juvenile population estimates provides ranges of 1 (6,560  $\div$  658,453) to 7 (6,560  $\div$  94,000) percent loss of the juvenile CCV steelhead population in the Delta for the COS, and 1 (7,988  $\div$  658,453) to 8 (7,988  $\div$  94,000) percent loss of the juvenile CCV steelhead population in the Delta for the PA. Because the revised loss thresholds in the original PA may limit loss to be more comparable with the COS scenario, the estimated screening-level population context under the final PA is likely less than the <1 to 8 percent estimated under the original PA.

### 2.8.5.3 Assess the Risk to the ESU/ DPS

To assess the risk posed by the PA to the DPS of CCV steelhead, when combined with the status of the species, environmental baseline, and cumulative effects, NMFS determines if changes in population viability, based on changes in the VSP parameters of that population, are likely to be sufficient to reduce the viability of the species. In this assessment, we use the species' status, based on the current condition of the VSP parameters, (established in in Section 2.2 The Status of the Species of the Species and Critical Habitat) as our point of reference for the effects of the PA. Currently the CCV steelhead DPS is at moderate risk of extinction (National Marine Fisheries Service 2016b). However, there is considerable uncertainty with regard to the magnitude of that risk, due in large part to the general lack of information and uncertainty regarding the status of many of its populations. Given this uncertain point of reference, but based on our knowledge of the population structure of the species, NMFS considers the consequences of a relative change in extinction risk to one or more of those populations and if that change would reduce appreciably the likelihood of both the survival and recovery of the species. Using the ESU/DPS-Level Recovery Criteria identified in the CCV steelhead 5-year status review (National Marine Fisheries Service 2016b), the combined risk to individual populations are evaluated to determine the risk to the DPS as a whole.

As described in the Recovery Plan, watersheds in the four diversity groups were prioritized into three categories (Table 2.8.5-3). Core 1 watersheds possess the known ability or potential to support a viable population. For a population to be considered viable, it must meet the criteria for low extinction risk for Central Valley salmonids (Lindley et al. 2007). Core 2 populations meet,

or have the potential to meet, the biological recovery standard for moderate risk of extinction. Core 3 watersheds have populations that are present on an intermittent basis and require straying from other nearby populations for their existence. These populations likely do not have the potential to meet the abundance criteria for moderate risk of extinction. Although Core 3 watersheds are the lowest priority, they remain important because so many historic populations have already been extirpated, and, like Core 2 watersheds, they support populations that provide increased life history diversity to the ESU/DPS and are likely to buffer against local catastrophic occurrences that could affect other nearby populations.

The diversity group and population priority lens helps put the PA's potential impact on the CCV steelhead DPS into context in two key ways. First, the importance of the Clear Creek population to the CCV steelhead DPS is illuminated given that it is identified as a "Core 1" population and is likely the only population in the Northwestern California diversity group with the potential to meet the recovery criteria calling for one viable population in the diversity group. The combined effect of multiple stressors on Clear Creek steelhead with implementation of the PA is expected to reduce the population's viability. Relative to the Clear Creek population, the PA's potential impact on CCV steelhead occurring in the Sacramento, American, and Stanislaus rivers carry slightly less weight. However, given that most historic independent CCV steelhead populations have already been extirpated, NMFS considers that an expected appreciable reduction in any population's viability due to implementation of the PA would also appreciably reduce the viability of the population's diversity group and the DPS.

The second way the diversity group/population priority lens provides context is that, while the Clear Creek population demonstrates the importance viable Core 1 populations for CCV steelhead, the DPS's survival and recovery is equally dependent on the occurrence of viable Core 2 populations in the San Joaquin River basin (i.e., southern Sierra Nevada diversity group). The expected impacts from the PA's increase in south Delta exports (albeit lessened by the revised loss thresholds in the OMR Management component of the final PA) and operation of south Delta agricultural barriers will likely inhibit populations in the southern Sierra Nevada diversity group. All of the juvenile CCV steelhead from the southern Sierra Nevada diversity group will be exposed to export-related impacts by either going by the "front door" of the export facilities via the Old River route since the PA has no HORB in place to block that route, or via the "backdoor" from the mainstem San Joaquin River if the fish stay in the SJR mainstem at the Head of Old River but then enter the interior channels of the south Delta at Turner Cut, Columbia Cut, or the mouths of Old River or Middle River. Any fish that goes the Old River route from the Head of Old River will more than likely be entrained into the TFCF or into CCF or predated upon trying to migrate north past the pumps. Fish in the mainstem San Joaquin River have a better chance to stay in the mainstem and survive to Chipps Island.

The effects of the PA are expected to cause additional harm to the DPS, which is already at high extinction risk due to a harmful environmental baseline. While several factors contribute to that harmful environmental backdrop, the construction and operation of the CVP/SWP is prominent. The continued operation of the CVP/SWP as proposed in the ROC on LTO BA, based on the effects and VSP-based analyses, would likely decrease its likelihood of survival and recovery.

Table 2.8.5-3. Central Valley Steelhead Diversity Groups and Watershed Prioritization. Divisions included in the PA are bold (modified from NMFS 2014).

Diversity Group	River or Creek	Priority
(number of viable populations needed to meet ESU level recovery criteria)		
Basalt and Porous Lava (2)	Battle Creek	Core 1
	Cow Creek	Core 2
	Sacramento River (downstream from Keswick)	Core 2
	Redding Area Tributaries	Core 2
Northwestern California (1)	Putah Creek	Core 2
	Thomes Creek	Core 2
	Cottonwood/Beegum Creek	Core 2
	Clear Creek	Core 1
Northern Sierra Nevada (4)	Mokelumne River (downstream from Comanche)	Core 2
	American River (downstream from Nimbus)	Core 2
	Auburn Ravine	Core 2
	Feather River (downstream from Oroville)	Core 2
	Yuba River downstream from Englebright)	Core 2
	Butte Creek	Core 2
	Big Chico	Core 2
	Deer Creek	Core 1
	Mill Creek	Core 1
	Antelope Creek	Core 1
Southern Sierra Nevada (2)	Calaveras River (downstream from New Hogan)	Core 1
	Stanislaus River (downstream from Goodwin)	Core 2
	Tuolumne River (downstream from La Grange)	Core 2

Diversity Group  (number of viable populations needed to meet ESU level recovery criteria)	River or Creek	Priority
	Merced River (downstream from Crocker Huffman)	Core 2

The VSP analysis shows that elements of the PA are expected to appreciably reduce the abundance VSP parameter for CCV steelhead populations of the Sacramento River and San Joaquin River basin, those of the Basalt and Porous Lava, Northwestern California, and Northern and Southern Sierra Nevada diversity groups. The VSP analysis shows that productivity, spatial structure, and diversity under the COS are currently degraded in the Sacramento River and San Joaquin River such that CCV steelhead remain at moderate risk of extinction (National Marine Fisheries Service 2016b). These VSP parameters are unlikely to improve under the PA and would likely deteriorate under increased water demands and climate change scenarios over the next decade. California's human population growth (see Section 2.7 Cumulative Effects) and the associated increase in water demand and climate change, will exacerbate risks associated with the PA, further increasing the risk to the population. In particular, the water temperature impacts expected with PA implementation are likely to be amplified by climate change.

The PA is expected to expose individual CCV steelhead from Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River to stressors that have fitness consequences for each inland life stage. Cumulatively, these fitness reductions throughout the inland CCV steelhead life cycle, are expected to result in population level consequences for each of the four populations, reducing their viability. For Central Valley ESUs and DPSs, reductions in population viability are assumed to also reduce the viability of the diversity group the population belongs to as well as the species. Because the four diversity groups with extant CCV steelhead populations are represented by these four populations³¹, the viability of all four extant CCV steelhead diversity groups is expected to be decreased with implementation of the PA. In consideration of the status and baseline stress regime of the species, these diversity group- and population-level consequences identified above reduce the likelihood of survival and recovery of the species. Considering the effects of the PA, cumulative effects, and effects from interrelated and independent actions in the context of the status and environmental baseline of CCV steelhead, NMFS concludes that the PA is likely to appreciably reduce the likelihood of both the survival and recovery of the CCV steelhead DPS (Table 2.8.5-4).

Table 2.8.5-4. Reasoning and decision-making steps for analyzing the effects of the proposed action on steelhead. Dark shading identifies the conclusion at each step of decision-making. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and not likely/likely to jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if	True/False	Action
Α	355 Y	True	End

³¹ Clear Creek belongs to the Northwestern California diversity group; the mainstem Sacramento River population belongs to the Basalt and Porous Lava diversity group; the American River belongs to the Northern Sierra Nevada diversity group; and the Stanislaus River belongs to the Southern Sierra Nevada diversity group.

Step	Apply the Available Evidence to Determine if	True/False	Action
	The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.  Available Evidence: Proposed action-related stressors adversely affecting the environment include: (1) Sacramento River, Clear Creek, and Stanislaus River flow regulation disrupting natural river function and morphology; (2) warm water temperatures in the mainstem Sacramento River, Clear Creek, the American River, and the Stanislaus River; (3) low late-summer flows in Clear Creek and in the American and Stanislaus rivers; and (4) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants).	False	Go to B
	CV steelhead individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.  Available Evidence: (1) All freshwater life stages of Sacramento River, Clear Creek, and Stanislaus River steelhead will be exposed to regulated flows and their effects on river processes and morphology every year through 2030. (2) Each year through 2030, steelhead in Clear Creek, the mainstem Sacramento River, the	True	В
	American River, and the Stanislaus River are expected to be exposed to water temperatures warmer than life stage-specific requirements during multiple life stages, including egg incubation and juvenile rearing. (3) Steelhead rear in their natal stream year-round for 1 to 2 years, and thus are expected to be exposed to low late-summer flows in Clear Creek and in the American and Stanislaus rivers. (4) As water is moved from the north Delta and from the San Joaquin River to the Federal and State export facilities, each year through 2030, CCV steelhead juveniles will have increased exposure to an abundant predator community, an aquatic environment degraded by pesticides and contaminants, and entrainment and loss at the facilities.	False	Go to C
	CV steelhead individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action.  Available Evidence: (1) Loss of natural river function resulting from flow regulation in the Sacramento River, Clear Creek, and the Stanislaus River has reduced the quality and quantity of rearing and migratory habitats, thereby reducing the growth and survival of individual steelhead juveniles in those systems. (2) Exposure to warm water temperatures in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River is expected to	True	NLAA
С	cause eggs deposited later (i.e., March) in the spawning season to suffer increased mortality and structural deformities during incubation, particularly during critically dry years. Thermal stress responses (e.g., reduced immune system function) are also expected to occur in individual juvenile CCV steelhead rearing over the summer in Clear Creek and the American River. (3) Low late-summer flows limit the availability of quality rearing habitat, including predator refuge areas. Under these low flow conditions, juvenile steelhead have an increased susceptibility to predation and density dependent related factors (e.g., disease and competition for prey and habitat). (4) Mortality of juvenile steelhead migrating from the San Joaquin River to Chipps Island is expected to range from 45 to 85 percent based on results from acoustic tag studies. Mortality of salmonids (~155 mm LFR Chinook salmon study fish) that enter the Delta interior from the Sacramento River is expected to range from 66-96 percent, resulting in the loss of approximately 13 -19 percent of the Sacramento River basin population of the California Central Valley DPS, assuming an average routing of 20 percent of migrating fish into the Delta interior.	False	Go to D

Step	Apply the Available Evidence to Determine if	True/False	Action
	Any responses are not likely to constitute "take" or reduce the fitness of the	True	NLAA
D	CCV steelhead individuals that have been exposed.  Available Evidence: (1) "Take" of steelhead individuals in the form of reduced growth and survival is expected due to the loss of natural river function associated with flow regulation in the Sacramento River, Clear Creek, and the Stanislaus river. (2) and (3) As described in step C, "take" of steelhead individuals, in the form of mortality and sub-lethal effects, is expected with exposure to warm water temperatures particularly during the egg incubation and juvenile rearing life stages, and with exposure to low flows during juvenile rearing. (4) As described in step C, "take" of steelhead individuals, in the form of mortality, is expected in the Delta during juvenile rearing/smolt emigration.	False	Go to E
	Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent.  Available Evidence: The cumulative effects of flow regulation, warm water temperatures, low flows, project-related impacts in the Delta, and other project-related stressors (see Table 2.8.5-2) are expected to sufficiently reduce the	True	NLJ
Е	survival, growth, and/or reproductive success of steelhead individuals at multiple life stages every year through 2030 such that key population parameters (i.e. spatial structure, diversity, and abundance) are appreciably reduced for steelhead populations in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River. Reductions in these parameters are of sufficient magnitude for one to reasonably expect a reduction in the viability of each of the four populations.	False	Go to F
	Any reductions in the viability of the exposed populations are not likely to reduce the viability of CCV steelhead the species.  Available Evidence: Considering the greatly diminished status of the CCV	True	NLJ
F	steelhead DPS, NMFS assumes that if a population-level effect on any of the populations within the DPS is expected from implementation of the proposed action, then a species-level effect will be expected as well. The proposed action is expected to reduce the viability of at least four steelhead populations. Therefore, the viability of the DPS is expected to be significantly reduced with implementation of the proposed action.	False	LJ

## 2.8.6 CCV Steelhead Critical Habitat

Designated critical habitat (70 FR 52488 2005).

## 2.8.6.1 Status of Critical Habitat and Environmental Baseline

As described in section 2.2 Rangewide Status of the Species and Critical Habitat, the geographical extent of designated critical habitat for CCV steelhead includes: the Sacramento, Feather, and Yuba rivers, and Deer, Mill, Battle, Clear, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries but excluding the mainstem San Joaquin River upstream of the Merced River confluence; and the waterways of the Delta. CCV steelhead critical habitat is composed of four physical or biological features that include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine habitat.

Stressors to CCV steelhead critical habitat PBFs include water diversions and water management, dams and other structures, loss of floodplain connectivity, loss of natural riverine

function, bank protection, dredging, sediment disposal, gravel mining, invasive aquatic organisms, and agricultural, urban, and industrial land use (McEwan 2001). The PBFs for the designated critical habitat were described for CCV steelhead in the following Federal Register notice: 70 FR 52488, September 2, 2005. CCV steelhead critical habitat includes the Delta – an ecosystem that has had dramatic habitat changes in recent years related to water quality, toxic algae blooms (e.g., Microcystis), and invasive species (e.g., the aquatic macrophyte Egeria densa). Based on the host of stressors to spawning, rearing, migratory, and estuarine habitats in the Central Valley, it is apparent that the current condition of CCV steelhead critical habitat is degraded, and does not provide the conservation value necessary for the survival and recovery of the species.

## 2.8.6.2 Summary of Proposed Action Effects on Critical Habitat

Proposed action-related effects to CCV steelhead designated critical habitat are summarized in Table 2.8.6-1. Detailed descriptions regarding the effects of the PA on CCV steelhead designated critical habitat are presented in section 2.6.

Table 2.8.6-1. Summary of proposed action-related effects on CCV steelhead critical habitat.

-			1		,		
Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Trinity (Clear Creek)	Division
Spring attraction pulse flows	Channel maintenance pulse flows	Spring attraction pulse flows	Spring attraction pulse flows	Water temperature management: summer	Minimum instream base flows	Water temperature management: summer	Action Component
Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek	Clear Creek-	Location of Effect
Fresh water spawning sites	Fresh water rearing sites	Fresh water rearing sites	Fresh water rearing sites	Freshwater migration corridors	Fresh water spawning sites	Fresh water rearing sites	PBFs Affected
Pulse flows mobilize and disperse some spawning gravel, and decrease fines, which improve spawning habitat.	Ramp down following pulse flow create stranding habitat.	Ramp down following pulse flow create stranding habitat.	Pulse flows mobilize some gravel to form new habitat, and will temporarily increase rearing habitat availability.	Warm water may block adult migration near mouth	Base flows provide suitable spawning habitat but lack variation that provides habitat complexity. In Critical water year types, reduced base flows will degrade spawning habitat.	Warm water temperatures downstream of compliance point degrade rearing habitat.	Response and Rationale of Effect
Low	Low	Low	Low	Low	Low	Low	Magnitude
Medium	Low	Low	Low	Low	Low	Medium	Weight of Evidence
Some increased quality and quantity of spawning habitat.	Degraded rearing habitat	Degraded rearing habitat	Improved connectivity to rearing habitat temporarily	Degraded migratory corridor.	Reduced quality of spawning habitat.	Reduced quality of rearing habitat	Probable Change in PBF Support in the Life History Needs of the Species

Fresh water  Pulse flows mobilize ar spawning sites disperse some spawning gravel, and decrease fines, which can improve spawning habitat.  Magnitude and duration is not likely to be great enough to shape the channel and adequately route spawning gravel and improve spawning habitat.	0004000 001400 No. 8000 No. 8000 No. 800 NO.
se and Rat of Effect	ionale Magnitude
	ale  nd Lo,  ve
Weight of Evidence  Medium	

Shasta		
ta		Division
Fall and Winter Refill and Redd Maintenance (2.5.2.1.4.1)		Action Component
Upper Middle Sacramento River		Location of Effect
Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean, Freshwater Migration		PBFs Affected
Decreased flows in September and November resulting in increased travel time and a decrease in survival because of increased predator interactions.		Response and Rationale of Effect
Medium		Magnitude
Medium: Supported by select technical publications specific to the region and species. Quantitative results include month to month to month change.	month change.	Weight of Evidence
Decreased flow limiting the downstream transport of juveniles		Probable Change in PBF Support in the Life History Needs of the Species

Division  Action Component  Effect  Description  Action Component  Effect  Description  Action Component  Effect  Description  Shastat  Sparing Pulse Flow  Sharamento Sparing Pulse Flow Sucamento Sparing Pulse Flow Successful Adequate river Adequate river Eggs, fry  and Redd Maintenance Shastat  Eall and Winter Refill Upper and Redd Maintenance (2.5.2.1.4.1)  Shastat  Fall and Winter Refill Upper and Redd Maintenance (2.5.2.1.4.1)  Eall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shastat  Fall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shastat  Fall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shastat  Fall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shawang Sites  Shastat  Fall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shawang Sites  Shawang Sites  Shawang Sites  Shawang Sites  Fall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shawang Sites  Shawang Sites  Fall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shawang Sites  Shawang Sites  Shawang Sites  Shawang Sites  Fall and Winter Refill Upper and Redd Maintenance Shawang Sites  Shawang Sites  Shawang Sites  Fall and Winter Refill Upper Adequate river Spawang Sites  Shawang Sites  Shawang Sites  Fall and Winter Refill Upper Adequate river Spawang Sites  Shawang Sites  Shawang Sites  Shawang Sites  Fall and Winter Refill Upper Adequate river Spawang Sites  Shawang Sites  Shawang Sites  Fall and Winter Refill Upper Adequate river Spawang Sites  Shawang Sites  Shawang Sites  Adequate river Spawang Sites  Shawang Sites  Shawang Sites  Adequate river Spawang Sites  Adequate		analysis.						
Bivision  Action Component  Effect  Spring Pulse Flow  Upper  Spring Pulse Flow  Signamento (2.5.2.1.2.1)  Spring Pulse Flow  Signamento (2.5.2.1.2.1)  Spring Pulse Flow  Signamento Spring Pulse Flow  Signamento Signamen		WUA			Spawning Sites			
Division   Action Component   Location of Effect   Effect   Effect		include			Freshwater			
Division  Action Component  Division  Division  Action Component  Division  Division  Action Component  Division  Action Component  Division  Divisi		results			juveniles,			
Division  Action Component  Division  Spring Pulse Flow Spring Pulse Flow Sacramento Clean gravel for provide flows high Scaramento Clean gravel for provide flows high Substrate, Substrate, Substrates Supported by multiple Successful Increased habitat Cower flows providing Substrates Supported S	and emergence	Quantitative			transport of			
Division  Action Component  Effect  Spring Pulse Flow  Spring Pulse Flow  (2.5.2.1.2.1)  Spring Pulse Flow  Clean gravel for provide flows high fine successful spawning.  Incubation of excessful and Redd Maintenance (2.5.2.1.4.1)  Fall and Winter Refill  Part Adequate river and cegs, fry eggs, fry mothation of eggs, fry enoughtions, and energence, and development and energence, and component and energence, a	development	and species.			and downstream			
Division  Action Component  Location of Effect  Spring Pulse Flow (2.5.2.1.2.1)  Upper (2.5.2.1.2.1)  Sacramento clean gravel for provide flows high plant flows for successful and Rationale (2.5.2.1.2.1)  Sucramento flows for flows from spawning substrates.  Spring pulse flow could flows high clean gravel for provide flows high enough to flush fine successful spawning.  Sucramento flows for flows from spawning substrates.  Fall and Winter Refill Spawning.  Fall and Winter Refill Upper Spawning.  Fall and Winter Refill Up	eggs, fry	the region			and emergence,			
Division  Action Component  Effect  Spring Pulse Flow  Upper (2.5.2.1.2.1)  Sacramento (2.5.2.1.2.1)  Spring Pulse Flow  Upper (2.5.2.1.2.1)  Spring Pulse Flow  Spring Pulse Flow  Spring Pulse Flow  Spring Pulse Flow  PBFs Affected  Spring pulse flows could clean gravel for provide flows high spawning substrate, and equate river and emergence, and downstream transport of juveniles, Festiwater  Fall and Winter Refill  Upper  Fall and Winter Refill  Upper  Action Component  Availability of provide flows high enough to flush fine substrates.  Spring pulse flows could Medium  Correlation of provide flows high enough to flush fine substrates.  Spawning substrates.  Spawning substrates.  Spawning substrates.  Festivate and downstream transport of juveniles, Freshwater  Spawning slites  Fall and Winter Refill  Upper  Adequate river  Spawning slites  Festivate and convertion and emergence, and downstream transport of juveniles, Freshwater  Spawning slites  Festivate and technical increased habitat  Low  Supported by multiple scientific and technical increased competition  PBFs Affected  Availability of privide flows high enough to flow high enough of the first supported by supported by supported increased competition  PBFs Affected  Availability of privide flows high enough to first flows for carrying capacity (WUA)  Low  Supported by the first flows for carrying capacity (WUA)  Low  Supported  Supported by thick flows providing increased feeding and technical publications in the first flows for carrying capacity (WUA)  Low  Supported by the first flows for carrying capacity (WUA)  Low  Supported by the first flows for carrying capacity (WUA)  Low  Supported by the first flows for carrying capacity (WUA)  Low  Supported by the first flows for carrying capacity (WUA)  All of the first flows for carrying capacity (WUA)  Low  Supported by the first flows for carrying capacity (WUA)  Low  Supported by the first flows flows for carrying capacity (WUA)  Low  Supported by the first flows flows for carrying capacity (WUA)  Low	писираноп от	specific to		and predation.	пелеторшени			
Division  Action Component  Effect  Division  Action Component  Division  Action Component  Effect  Division  Action Component  Effect  Spring Pulse Flow (2.5.2.1.2.1)  Sacramento clean gravel for provide flows high enough to flush fine spawning spawning.  Incubation of eggs, fry development and emergence, and demergence, and demergence, and demergence, and demergence, and demergence, and demergence, and flows for spawning.  Fall and Winter Refill and Redd Maintenance (2.5.2.1.4.1)  Fall and Winter Refill incubation of flows providing increased feeding spawning, incubation of decreased competition incubation of provide flows from spawning.  Fall and Winter Refill incubation of flows providing increased feeding spawning.  Fall and Edd Maintenance incubation of successful and decompletion incubation of the flows from spawning.  Fall and Winter Refill incubation of successful and decompletion incubation of the flows from spawning.  Fall and Winter Refill incubation of successful and decompletion incubation of the flows from spawning increased flows flow sproviding increased flows flow phy multiple scientific and technical incubation of the flows flow spawning increased flows flow spawning increas	incubation of	Pagific to		and production	davelament			
Division  Action Component  Effect  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Sacramento (2.5.2.1.2.1)  Spawning (2.5.2.1.2.1)  Medium  Correlation (2.5.2.1.2.1)  Medium  Correlation (2.5.2.1.2.1)  Substrates.  Spawning (2.5.2.1.2.1)  Medium  Correlation (2.5.2.1.2.1)  Medium  Correlation (2.5.2.1.2.1)  Substrates.  Spawning (2.5.2.1.2.1)  Spa	spawning.	publications		decreased competition	eggs, frv			
Division         Action Component         Location of Effect         PBFs Affected         Response and Rationale of Effect         Magnitude         Weight of Evidence           Spring Pulse Flow (2.5.2.1.2.1)         Upper Sacramento Sacramento Sites Adequate river substrate, and control of flow and excessful spawning. Incubation of eggs, fry development and emergence, and downstream transport of Juveniles, Fall and Winter Refill And Redd Maintenance (2.5.2.1.4.1)         Medium Spring pulse flows could provide flows high enough to flush fine substrates.         Medium Spawning Sites Spawning sediments from spawning substrates.         Medium Spawning Sites Spawning sediments from spawning substrates.         Medium Spawning Spawning sediments from spawning substrates.         Medium Supported by supported by supported by supported spawning substrates.         Medium Supported Spawning Substrates.         Medium Supported Spawning Substrates.         Medium Supported Spawning Substrates.         Medium Supported Spawning Supported Spawning Supported Spawning Substrates.         Medium Supported Spawning Substrates.         Medium Supported Spawning Supported Spawning Supported Spawning Substrates.         Medium Supported Spawning Spawning Supported Spawning Supported Spawning Spawning Supported Spawning Supported Spawning Supported Spawning Supported Spawning Supported Spawning	successful	and technical		conditions, and	incubation of			
Action Component Effect    Division   Action Component   Effect	necessary for	scientific		increased feeding	spawning,			
Division         Action Component         Location of Effect         PBFs Affected         Response and Rationale of Effect         Magnitude         Weight of Evidence           Spring Pulse Flow (2.5.2.1.2.1)         Upper Sacramento (2.5.2.1.2.1)         Availability of Sacramento substrate, (2.5.2.1.2.1)         Spring pulse flows high revoide flows high revoide flows high revoide flows high revoide flows for substrate, substrates.         Medium: Correlation of provide flows high revoide flows from spawning supported by substrates.         Medium: Correlation of flow and the sediments from spawning supported by substrates.         Medium: Correlation of flow and the sediments from spawning supported by substrates.         Incubation of evelopment and emergence, and evenies, flow safer transport of juveniles, from spawning sites         Incubation of juveniles, from spawning sites         Incubation of juveniles, from spawning sites         Increased habitat town supported	capacity	by multiple		at lower flows providing	successful	River	(2.5.2.1.4.1)	
Division         Action Component         Location of Effect         PBFs Affected         Response and Rationale of Effect         Magnitude         Weight of Evidence           Spring Pulse Flow (2.5.2.1.2.1)         Upper Sacramento (2.5.2.1.2.1)         Availability of Sacramento Sacramento (2.5.2.1.2.1)         Spring pulse flows could spawning spawning spawning spawning spawning spawning successful spawning incubation of flows for spawning	habitat carrying	Supported		carrying capacity (WUA)	flows for	Sacramento	and Redd Maintenance	
Division Action Component Effect    Division   Action Component   Effect   Effect	Increased	High:	Low	Increased habitat	Adequate river	Upper	Fall and Winter Refill	Shasta
Division  Action Component  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Sucramento spawning Adequate river flows for spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater  Spring Pulse Flow (2.5.2.1.2.1)  Spring pulse flows could clows high clows high enough to flush fine substrate, substrates.  Magnitude Evidence  Evidence  Spring pulse flows could move flows high enough to flush fine substrates.  Spring pulse flows could move flows high enough to flush fine substrates.  Spring pulse flows could move flows high enough to flush fine substrates.  Spring pulse flows could magnitude of flow and enigration in transport of the flush from spawning substrates.  Spring pulse flows could magnitude of benefit uncertain.					Spawning Sites			
Division  Action Component    Division   Action Component   Effect					Freshwater			
Division         Action Component         Location of Effect         Response and Rationale Component Effect         Weight of Evidence         Index					juveniles,			
Division  Action Component  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow Sacramento Sacrament					riansport or			
Division         Action Component         Location of Effect         PBFs Affected         Response and Rationale of Effect         Magnitude         Weight of Evidence           Spring Pulse Flow (2.5.2.1.2.1)         Upper Sacramento (2.5.2.1.2.1)         Availability of Sacramento clean gravel for substrate, Adequate river successful spawning, incubation of eggs, fry degree, and emergence, and downstream         Spring pulse flows could enough to flows high enough to flows high enough to flow shigh escientific spawning, incubation of eggs, fry degree, and emergence, and downstream         Medium         Medium: Correlation of evidence         Imagration substrates.					transport of			
Division  Action Component  Effect  C2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow Sacramento Clean gravel for Spawning River  Substrate, Adequate river flows for spawning, includation of eggs, fiy eggs, fiy development and emergence, and technical magnitude of benefit  Action Component  Location of Effect  Response and Rationale of Effect  Response and Rationale Medium  Correlation of flows high enough to flush fine substrates.  Spring pulse flows could Medium  Correlation of enough to flush fine substrates.  Supported by substrates.		uncertain.			and downstream			
Division         Action Component         Location of Effect         PBFs Affected         Response and Rationale of Effect         Magnitude         Weight of Evidence           Spring Pulse Flow (2.5.2.1.2.1)         Upper Sacramento (2.5.2.1.2.1)         Availability of Clean gravel for spawning and spawning (2.5.2.1.2.1)         Spring pulse flows could provide flows high enough to flush fine substrate, substrate, substrates.         Medium Correlation of flow and enough to flush fine substrates.         Correlation of supported by substrates.           spawning, incubation of eggs, fry development         eggs, fry development         substrates.         and technical publications but magnitude of magnitude of		benefit			and emergence,			
Division       Action Component       Location of Effect       PBFs Affected       Response and Rationale of Effect       Magnitude       Weight of Effect         Spring Pulse Flow (2.5.2.1.2.1)       Upper Sacramento (2.5.2.1.2.1)       Availability of Sacramento spawning enough to flush fine substrate, Adequate river successful spawning, incubation of eggs, fry       Spring pulse flows could enough to flush fine sediments from spawning substrates.       Medium: Correlation of Evidence       Image: Correlation of Evidence (Evidence Evidence (Evidence Evidence Evidence (Evidence Evidence Evidence (Evidence Evi		magnitude of			development			
Division       Action Component       Location of Effect       PBFs Affected (2.5.2.1.2.1)       Response and Rationale (Effect)       Magnitude (Evidence)       Weight of Effect         Spring Pulse Flow (2.5.2.1.2.1)       Upper (2.5.2.1.2.1)       Availability of clean gravel for spawning (2.5.2.1.2.1)       Spring pulse flows could clean gravel for substrate, and equate river successful spawning, incubation of incubation of spawning, incubation of incubations       Spring pulse flows could end (and technical publications       Medium: Correlation of Effect       Image: Correlation of Effect       Medium: Correlation of Effect       Image: Correlation of Effect <td></td> <td>but</td> <td></td> <td></td> <td>eggs, fry</td> <td></td> <td></td> <td></td>		but			eggs, fry			
Division         Action Component         Location of Effect         PBFs Affected         Response and Rationale of Effect         Magnitude         Weight of Effect           Spring Pulse Flow (2.5.2.1.2.1)         Upper Sacramento (2.5.2.1.2.1)         Availability of Clean gravel for substrate, Adequate river flows for successful spawning,		publications			incubation of			
Division       Action Component       Location of Effect       PBFs Affected       Response and Rationale of Effect       Magnitude       Weight of Evidence         Spring Pulse Flow (2.5.2.1.2.1)       Upper Sacramento (2.5.2.1.2.1)       Availability of Spring pulse flows could square river flows for substrate, substrate, substrates.       Spring pulse flows could enough to flush fine substrates.       Medium Correlation of flow and migration substrates.		and technical			spawning,			
Division  Action Component  Effect  Castion of Effect  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow Availability of Sacramento spawning substrate, Adequate river flows for flows for flows for flows for substrates.  Action Component  Effect  Availability of clean gravel for substrates.  Adequate river flows substrates.  Response and Rationale Magnitude  Evidence  Veight of Evidence  Spring pulse flows could provide flows high enough to flush fine substrates.  Adequate river flow substrates.		SCIEDULIC			successiui			
Division  Action Component  Effect  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow Sacramento Sacramento Spring Pulse Flow Sacramento Sacramento Spring Pulse Flow Sacramento Sacramento Sacramento Spawning Substrate, Adequate river Substrates.  Action Component  Location of Effect  Response and Rationale Of Effect Spring pulse flows could Spring pulse flows could Spring pulse flows high Correlation of flow and migration Supported by Spring pulse flows could Spring pulse flows could Spring pulse flows high Spring pulse flows high Spring pulse flows shigh Spring p		muupie			HOWS IOI			
Division  Action Component  Effect  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Adequate river  Adequate river  Spring Pulse Flow (2.5.2.1.2.1)  Adequate river  Spring pulse flows could (2.5.2.1.2.1)  River  Adequate river  Spring pulse flows could (2.5.2.1.2.1)  Adequate river  Spring pulse flows could (3.5.2.1.2.1)  Magnitude  Evidence  Evidence  Spring pulse flows could (3.5.2.1.2.1)  Magnitude  Spring pulse flows could (4.5.2.1.2.1)  Medium:  Correlation  of flow and migration  Supported by  Supported b	anoanarc	supported by		sucou arcs.	Tacquare 11vc1			
Division  Action Component  Effect  Spring Pulse Flow (2.5.2.1.2.1)  Location of Effect  PBFs Affected of Effect  Availability of clean gravel for spawning enough to flush fine substrate sediments from gravaning endinces and Rationale Magnitude  Evidence  Spring pulse flows could PBFs Affected of Effect  Of Effect  Weight of Evidence Evidence  Spring pulse flows could Provide flows high enough to flush fine substrate sediments from gravaning enough to flush fine endinces the form gravaning enough to flush fine entered enough to flush fine enough to flush fine entered entered enough to flush fine entered enough to flush fine enough to flush fine entered enough to flush fine enough to flush f	enhetrate	supported by		substrates	Adequate river			
Division  Action Component  Effect  Spring Pulse Flow (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  Location of PBFs Affected Effect  PBFs Affected of Effect Spring pulse flows could (2.5.2.1.2.1)  PBFs Affected of Exponse and Rationale Spring pulse flows could (2.5.2.1.2.1)  Spring Pulse Flow (2.5.2.1.2.1)  River Spawning Spring pulse flows could (2.5.2.1.2.1)  River Spawning Spring pulse flows could (2.5.2.1.2.1)  River Spawning Spring pulse flows could Spring pulse flows high Correlation of flow and of flow and	of enguing	mioration		sediments from enguming	embetrate	ő		
Division  Action Component  Effect  Spring Pulse Flow (2.5.2.1.2.1)  Division  Action Component  Location of Effect  PBFs Affected of Effect  Spring pulse flows could (2.5.2.1.2.1)  Sacramento clean gravel for provide flows high  Response and Rationale of Evidence  Spring pulse flows could (2.5.2.1.2.1)  Weight of Evidence (2.5.2.1.2.1)	quantity/quality	of flow and		enough to flush fine	spawning	River		
Division  Action Component  Effect  Spring Pulse Flow  Upper  Location of Effect  PBFs Affected of Effect  Spring pulse flows could  Spring pulse flows could  Spring pulse flows could  Spring pulse flows could  Magnitude  Evidence  Spring pulse flows could  Medium:	improved	Correlation		provide flows high	clean gravel for	Sacramento	(2.5.2.1.2.1)	
Action Component Effect PBFs Affected Serious and Rationale Of Effect Response and Rationale Of Effect Weight of Evidence	Increased or	Medium:	Medium	Spring pulse flows could	Availability of	Upper	Spring Pulse Flow	Shasta
Action Component Effect PBFs Affected Sof Effect Response and Rationale of Effect Weight of Evidence	Species							
Action Component Location of PBFs Affected Action Component Fffect PBFs Affected of Evidence Evidence	Needs of the					THE CO.		
Togation of PREs Affected Response and Rationale Magnitude Weight of	Life History	Evidence		of Effect	T DI 9 MICCION	Effect	Action Component	211131011
Probable Change in PBF	Support in the	Weight of	Magnitude	Response and Rationale	DREs Affactad	I ocation of		Division
Probable	Change in PBF	1						
	Probable							

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Support in the Life History Needs of the Species
Shasta	Fall and Winter Refill and Redd Maintenance	Upper Middle Sacramento	Riparian habitat that provides for	Increased habitat carrying capacity (WUA)	Low	Medium: Supported	Increased access to riparian
	(2.5.2.1.4.1)	River	successful	at lower flows providing		by technical	habitat that
			juvenile	increased feeding		publications	provides for
			development	conditions, and		specific to	successful
			Freshwater	and predation		and species	development
			Rearing Sites			Quantitative	and survival
			21			results	
						include	
						WUA	
						analysis and	
						month to	
						month	
						inundation.	
Shasta	Spawning Gravel	Upper	Availability of	As part of adaptive	Low (Uncertain)	Low:	Increased or
	Injection (2.5.2.3.2.1)	Sacramento	clean gravel for	management reclamation		(Programmat	improved
			substrate.	spawning gravel		component)	of spawning
			Freshwater	injection project(s) in the		very little	substrate
			Spawning Sites	action area. This action		information	
				directly affect the		to how or	
				quantity and quality of		where this	
				available substrate		action	
				suitable for spawning.		component	
						would be	
						implemented	
						or the extent	
						of its effects.	

Shasta	Shasta	
sta	sta	Division
Small Screen Program (2.5.2.3.2.3)	Side-Channel habitat (2.5.2.3.2.2)	Action Component
Middle Sacramento River	Upper Middle Sacramento River	Location of Effect
Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean, Freshwater Migration Corridors	Availability of clean gravel for spawning substrate, Adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles, Freshwater Spawning Sites	PBFs Affected
Programmatic action component. Construction activities are not described but operation is assumed to comply with NMFS and CDFW fish screening guidance.	As part of adaptive management reclamation would implement side-channel habitat restoration project(s) in the action area. This action component would directly affect access to areas suitable for spawning which includes increased flow to those areas as well as the quantity and quality spawning substrate.	Response and Rationale of Effect
Low (Uncertain)	Low (Uncertain)	Magnitude
Low: (Programmat ic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Low: (Programmat ic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Weight of Evidence
Increased access to and through Freshwater Migration Corridors	Increased or improved quantity/quality of spawning substrate in freshwater spawning sites	Probable Change in PBF Support in the Life History Needs of the Species

Amer	Shasta	Shasta	
American River		****	Division
Water temperature management	Adult rescue (2.5.2.3.3.1.2)	Lower Intakes near Wilkins Slough (2.5.2.3.1.2)	Action Component
Nimbus to confluence	Middle Sacramento River	Middle Sacramento River	Location of Effect
Spawning/incub ation and freshwater rearing and migratory habitat	Access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River, Freshwater Migration Corridors	Access downstream so that juveniles can migrate from the spawning grounds to San Francisco Bay and the Pacific Ocean, Freshwater Migration Corridors	PBFs Affected
Incubation, rearing, and migration (smoltification) habitat may be degraded by temperatures especially in dry and critically dry years	Programmatic action component. Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of adult salmonids entrained in water diversions (e.g. Yolo and Sutter Bypasses).	Programmatic action component. Construction activities are not described but operation is assumed to comply with NMFS and CDFW fish screening guidance.	Response and Rationale of Effect
high	Low (Uncertain)	Low (Uncertain)	Magnitude
high- water temperature monitored/m odeled and in excess of suitable ranges of	Low: (Programmat ic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Low: (Programmat ic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Weight of Evidence
Reduced quality of incubation and rearing/smoltific ation habitat	Increased access to and through Freshwater Migration Corridors	Increased access to and through Freshwater Migration Corridors	Probable Change in PBF Support in the Life History Needs of the Species

the adult CCV steelhead	certain.
	steelhead migration behavior. Most of
ary ting	due to timing of juvenile CCV
Improved water quality the fall during the fall may improve transfer window	rove transfer window productivity
_	downstream in
umproved mixing of Basin population water column and water emigrating	
	Sacramento River
100	steelhead
conditions may improve juvenile CCV	
	affect a small
elements will	elements will papers
	and water quality
conditions may improve Improved flows	
access for rearing	restoration is ongoing, benefits
improved spawning medium substrate and floodplain	******
(lethal), fry and juvenile	operations
siltation or dewatering	
component. Redd	
programmatic action	
madium	
	stage in nearly all
Response and Rationale Magnitude	

Division	Action Component	Location of Effect	PBFs Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Probable Change in PBF Support in the Life History Needs of the Species
Delta	Contra Costa Water District-Rock Slough, Water Transfer, CVP	Freshwater Rearing Habitat for	Adequate river flows for successful	water transfers can benefit juvenile CCV steelhead migrating downstream in October and November, as well as adults migrating upstream due to stronger flow and olfactory cues. 5) Operations of NBA/Barker Slough Pumping Plant may delay migration of juveniles due to alterations to flow patterns created by the export of water  1) Increased exports during transfer window will increase the risk of water and the control of the co	travel distances and travel time). Adults that stray into the Mokelumne River system due to open gates and then encountering subsequently closed gates will be delayed in their upstream migration.	High - numerous studies have	River mainstem. Closed gates reduce the probability of adult straying and migration delay by closing off false attractant flows. Lesser effect in final PA due to revised DCC operations in December-January. Water transfers may enhance ambient Sacramento River flows, providing better freshwater migratory conditions for juvenile and adult SH. Increased exports entrain more fish into
Delta	Contra Costa Water District-Rock Slough, Water Transfer, CVP and SWP Export Facilities, South Delta Agricultural Barriers	Freshwater Rearing Habitat for Juveniles: San Joaquin Delta	Adequate river flows for successful downstream transport of juveniles; water quality and forage supporting juvenile salmonid development:	1) Increased exports during transfer window will increase the risk of entrainment of CCV steelhead juveniles; 2) Increased exports in general over the calendar year will increase CCV steelhead entrainment into the CVP and SWP facilities; 3) Operations of the south Delta	Medium - Most of the CCV steelhead population will remain in the north Delta and be minimally affected by operations in the South Delta. CCV steelhead from the San	High - numerous studies have examined the effects of the CVP and SWP export facilities, the south Delta agricultural barriers, and the survival	Increased exports entrain more fish into the CVP and SWP facilities, where loss occurs; lesser effect in final PA due to revised loss thresholds.

aoricultura	salmon)	proportion of the	barriers create barriers to	vegetation large	corridor for		
the south Delta	and Chinook	much greater	South Delta agricultural	objects, aquatic	migratory		
Construction of	(steelhead	basin will have a	Construction of the	large woody	Freshwater		
thresholds.	of salmonids	Joaquin River	can delay migration. 3)	overhanging	Bay -		
revised loss	the survival	from the San	localized conditions that	submerged and	Delta, and SF		
final PA due to	barriers, and	CCV steelhead	Slough diversion create	such as	mainstem,		
lesser effect in	agricultural	South Delta.	exports through the Rock	natural cover	Joaquin River -		
facilities; likely	south Delta	operations in the	(reverse flows), 2)	conditions and	and San		
the export	facilities, the	affected by	downstream to the ocean	quality	Sacramento		
downstream of	SWP export	be minimally	steelhead migration	quantity and	Adults:		
waterways	the CVP and	north Delta and	South Delta that impede	with water	Spawning	Agricultural Barriers	
in the	the effects of	remain in the	in the channels of the	excess predation	Juveniles and	Facilities, South Delta	
flow conditions	examined	population will	hydrodynamic conditions	obstruction and	Outmigrating	and SWP Export	
create reverse	studies have	steelhead	Export facilities create	corridors free of	Corridors for	Water Transfer, CVP	
exports will	numerous	of the CCV	the CVP and SWP	migration	Migratory	District-Rock Slough,	
Increased	High -	Medium - Most	Increased exports by	Freshwater	Freshwater	Contra Costa Water	Delta
would lavor							
quanty mat							
cuvii omiciiai			wetted chamber.				
environmental			mirasu ucinie in tile				
radicing the			infractructure in the				
fish while		La Promotoria	survival due to				
favor predatory		population.	predation, and reduce				
conditions that		of the overall	enhance exposure to				
habitat		smaller fraction	agricultural barriers				
and create		this represents a	as the South Delta				
impoundments,		quality, although	export facilities as well				
Canal through		rearing habitat	and CVP south Delta				
and Grant Line		reduction in	Operations of the SWP				
Middle River,		the concurrent	temperatures. 4)				
Old River,	Delta.	operations, and	increasing water				
the channels of	of the South	South Delta	quality and potentially				
water through	waterways	impacted by the	Delta, degrading water				
the flow of	through the	population	channels of the south				
barriers reduce	salmon)	proportion of the	residence time within				
Agricultural	and Chinook	much greater	and increase water				
the south Delta	(steelhead	basin will have a	reduce flow velocities				
and operation of	of salmonids	Joaquin River	agricultural barriers will				
Species							
Needs of the							
Life History	Evidence	Summan	of Effect		Effect	Action Component	21131011
Support in the	Weight of	Magnifude	Response and Rationale	PRFs Affected	Location of		Division
Change in PBF							

Delta		Division
Smelt Habitat (X2)		Action Component
and vicinity	adults and juveniles	Location of Effect
Steelhead PBFs: access to spawning areas, freshwater rearing sites, freshwater migratory corridors, and estuarine areas.	rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.	PBFs Affected
The action may result in changes to low salinity location, flow volume, and water temperatures. A small change in low salinity zone (X2) location would likely result in minimal effects to steelhead critical habitats. Water temperatures may be altered have an effect on prey abundance, water quality, and migration corridor. Short-term changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG are not expected to significantly change habitat availability or suitability for rearing of listed anadromous salmonids.	the downstream movement of juvenile steelhead and upstream movement of adult steelhead into the San Joaquin River basin	Response and Rationale of Effect
Low	population impacted by the South Delta operations, and the concurrent reduction in migratory corridor habitat quality, although this represents a smaller fraction of the overall population.	Magnitude
Low	through the waterways of the South Delta.	Weight of Evidence
Low	barriers create substantial migratory barriers to steelhead moving downstream in the waterways they occupy.	Probable Change in PBF Support in the Life History Needs of the Species

Delta 2 M D:	Delta 2. D. C. S. Ri S. S. S.	Delta 2.	Division
2.5.6.8.1.1.4 Suisun Marsh Roaring River Distribution System Food Subsidy Studies	2.5.6.8.1.1.4 North Delta Food Subsidies / Colusa Basin Drain and Suisun Marsh Roaring River Distribution System Food Subsidy Studies	2.5.6.8.1.1.3 Sacrament o Deep Water Ship Channel Food Study	Action Component
Suisun Marsh	North Delta	SDWSC downstream to Sacramento River confluence	Location of Effect
Steelhead PBFs: freshwater migratory corridors, water quality and forage, freshwater rearing sites, and migratory corridors free of obstructions.	Steelhead PBFs: freshwater migratory corridors, water quality, forage, freshwater rearing sites.	Steelhead PBFs: freshwater migratory corridors free of obstructions, water quality and forage, and rearing habitat.	PBFs Affected
Fish passage will be affected by the operation of the SMSCG. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 70-80 days of annual operation. However, these changes in water	Water quality would be temporarily affected by the Colusa Basin drainage into the N Delta which would temporarily expose fish to agricultural drainage water potentially containing contaminants (pesticides, nutrients) during 2 months of the year. Exposure would be limited and temporary and would not likely affect survival.	Reconnecting the SDWSC to the Sacramento River will allow flow through the ship channel which will improve conditions (water temp, flow), but will impact habitat downstream by mobilizing contaminants and other water quality parameters.	Response and Rationale of Effect
Low	Low	Low	Magnitude
Low	Low	Low	Weight of Evidence
Low	Low	Low	Change in PBF Support in the Life History Needs of the Species

East Side Division/Stanislaus	East Side Division/Stanislaus	East Side Division/Stanislaus		Division
Seasonal operations and Stepped Release Plan Reduction in channel forming flows	Seasonal operations and Stepped Release Plan Lack of overbank flow to inundate rearing and migratory habitat	Seasonal operations and Stepped Release Plan Water temperatures warmer than life history stage requirements		Action Component
Goodwin Dam to confluence	Goodwin Dam to confluence	Goodwin Dam to Orange Blossom Bridge		Location of Effect
Freshwater rearing sites & freshwater migration corridor	Freshwater rearing sites & freshwater migration corridor	Freshwater spawning sites		PBFs Affected
Reduction in rearing and migratory habitat complexity and associated physical habitat conditions that support juvenile growth, mobility, and survival	Limited connectivity to shallow-water habitat (side-channels or floodplain) limits access to habitat conditions that support juvenile growth, mobility, and survival	Reduced suitable habitat for spawning, incubation, and larval development.	flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Short-term changes in tidal flow are not expected to significantly change habitat availability or suitability	Response and Rationale of Effect
High	High	High		Magnitude
Medium	Medium	Medium		Weight of Evidence
Reduced quantity and quality of rearing habitat and migratory habitat	Reduced quantity and quality of rearing habitat and migratory habitat	Reduced quantity and quality of spawning and incubation habitat		Change in PBF Support in the Life History Needs of the Species

Eastside Division/ Stanislaus Stanislaus Stanislaus River Dissolved Oxygen Requirement  Requirement	East Side Seasonal operations and Division/Stanislaus Stepped Release Plan to confluence Water temperatures warmer than life history stage requirements	East Side Conservation Measure – Goodwin Dam Division/Stanislaus Spawning and Habitat to Orange Restoration Spawning Blossom Habitat Blossom	East Side Seasonal operations and Goodwin Dam Division/Stanislaus Stepped Release Plan to Orange water temperatures Blossom warmer than life history Bridge stage requirements	East Side Division/Stanislaus Stepped Release Plan Excessive fines in spawning gravel resulting from lack of overbank flow  Seasonal operations and to Orange Blossom Bridge	Action Component Effect
en en	s and lan s story	e e	s and lan story	, h /#=	50,170
at Ripon freshwater rearing sites, water quality, and freshwater migration corridors	win Dam Freshwater fluence migration corridors	win Dam Freshwater spawning sites om e	win Dam Freshwater rearing sites om e	win Dam Freshwater spawning sites om e	Effect
Fs: Potentially reduce dissolved oxygen at Ripon (and downstream) by approximately 1 to 2 mg/L during summer months. Temporary and small change in DO.  Would minimally affect CH.	Water temperatures in late spring may be unsuitable for smoltification or, more rarely, migration.	Increased suitable spawning habitat	Rearing habitat may be degraded by temperatures, especially in the summer	Reduced suitable habitat for spawning, incubation, and larval development.	of Effect
Low	Low	Medium	Medium	Medium	9
Medium	Medium	High	Medium	Medium	Evidence
Low	Reduced quantity and quality of migratory habitat.	Increased quantity and quality of spawning habitat	Reduced quantity and quality of rearing habitat	Reduced quantity and quality of spawning and incubation habitat	Life History Needs of the Species

habitat			corridor			
		by temperatures, primarily March-June	migration migration	Mossdale	than life history stage requirements	
Medium	Medium	Rearing and migratory habitat may be degraded	Freshwater rearing sites &	Confluence of Stanislaus to	PA Conditions water temperatures warmer	San Joaquin River
Medium	High	Reduction in rearing and migratory habitat complexity and associated physical habitat conditions that support juvenile growth, mobility, and survival	Freshwater rearing sites & freshwater migration corridor	Confluence of Stanislaus to Mossdale	PA Conditions Reduction in channel forming flows	San Joaquin River
Medium	High	Limited connectivity to shallow-water habitat (side-channels or floodplain) limits access to habitat conditions that support juvenile growth, mobility, and survival	Freshwater rearing sites & freshwater migration corridor	Confluence of Stanislaus to Mossdale	PA Conditions Lack of overbank flow to inundate rearing and migratory habitat	San Joaquin River
High	Low	Increased turbidity and other behavioral disruptions due to inwater work.	Freshwater spawning sites, freshwater rearing sites & freshwater migration corridor	Goodwin Dam to confluence	Conservation Measure – Spawning and Habitat Restoration Construction	East Side Division/Stanislaus
High	Low (due to extent of restoration compared to length of river)	Improvements shallow- water habitat (side- channels or floodplain) increases access to habitat conditions that support juvenile growth, mobility, and survival	Freshwater rearing sites & freshwater migration corridor	Goodwin Dam to confluence	Conservation Measure – Spawning and Habitat Restoration Rearing Habitat	East Side Division/Stanislaus
Weight of Evidence	Magnitude	Response and Rationale of Effect	PBFs Affected	Location of Effect	Action Component	Division

### 2.8.6.3 Status and Risk to Critical Habitat by Division

### 2.8.6.3.1 Clear Creek

### 2.8.6.3.1.1 Status of CCV Steelhead Critical Habitat in Clear Creek

The PBFs of CCV steelhead habitat in Clear Creek include freshwater spawning, rearing, and migration. Whiskeytown Dam, located at river mile18.3 on Clear Creek, is an impassable barrier to adult anadromous salmonids and marks the upstream extent of potential CCV steelhead habitat. The McCormick-Saeltzer Dam blocked upstream migration of anadromous salmonids from 1903 until it was removed in the fall of 2000. Following its removal, approximately 12 miles of coldwater habitat upstream to Whiskeytown Dam was available. The construction of Whiskeytown Dam, gold mining, and significant gravel mining in the Clear Creek watershed has diminished the availability and recruitment of suitable spawning gravels. Channel restoration and gravel injection projects are conducted to make up for this loss of spawning gravel recruitment and suitable spawning habitat on Clear Creek.

Currently the release schedule from Whiskeytown Dam calls for flows of 200 cfs from October 1 to June 1, and 150 cfs from July through September in order to maintain water temperatures below 60°F from June 1 through September 15, and 56°F through October 31. Under dry and warm climate conditions, water temperatures above 60°F occur in lower Clear Creek. Lindley et al. (2004) suggested that Clear Creek appears to offer habitat of marginal suitability to CCV steelhead, with suitability of lower elevations habitats being highly dependent on rainfall and flow releases from Whiskeytown Dam.

### 2.8.6.3.1.2 Project Effects on CCV Steelhead Critical Habitat in Clear Creek

The PA produces stressors to CCV steelhead critical habitat in Clear Creek that primarily affect rearing habitat. Flow regulation impairs natural river processes and decreases habitat complexity and variability, which limits the quality and quantity of rearing habitat. Additionally, low flows and warm water temperatures during the summer limit the availability of quality rearing habitat.

### 2.8.6.3.1.3 Assess Risk to CCV Steelhead Critical Habitat in Clear Creek

Habitat in Clear Creek below Whiskeytown Dam is believed to be historically unsuitable for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on Clear Creek must be maintained by releases from Whiskeytown Dam and any level of degradation to the functioning of that habitat further limits its conservation value. The PA proposes to maintain suitable minimum base flow and temperature management in Clear Creek, and includes channel maintenance and spring attraction pulse flows. Under the PA, spring attraction and channel maintenance pulse flows are expected to improve spawning habitat quality and quantity by mobilizing and dispersing gravel, and reducing fine sediment, and provide improvements to juvenile rearing habitat, and the fresh water migratory corridor. Channel maintenance pulse flows under the PA will not occur in Critical and Dry water year types, and would not provide the magnitude needed for channel shaping and floodplain inundation (3,000 to 6,000 cfs) because releases are limited by the outlet capacity at Whiskeytown Dam (900 cfs). High flows also may diminish habitat due to redd scour.

### 2.8.6.3.2 Mainstem Sacramento River

## 2.8.6.3.2.1 Status of CCV Steelhead Critical Habitat in the Mainstern Sacramento River

Within the range of CCV steelhead, biological features of the designated critical habitat that are considered vital for CCV steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine habitat. As generally described above in section 2.6, the status of critical habitat in each of these biological features is considered to be degraded. Negative effects to rearing and migration habitats within the Sacramento River include loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use.

# 2.8.6.3.2.2 Project Effects on CCV Steelhead Critical Habitat in the Mainstem Sacramento River

The PA negatively affects critical habitat for CCV steelhead from the mainstem Sacramento River in several ways. As shown in Table 2.8.6-1, the PA produces stressors to CCV steelhead spawning, rearing, and migratory habitat in the middle and lower reaches of the mainstem Sacramento River.

# 2.8.6.3.2.3 Assess Risk to CCV Steelhead Critical Habitat in the Mainstem Sacramento River

Habitat within the mainstem Sacramento River below Shasta Dam is believed to be historically unsuitability for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on the mainstem Sacramento River must be maintained by releases from Keswick Dam and any level of degradation to the functioning of that habitat further limits its conservation value. The PA proposes some reduction in suitability of rearing habitat in the middle Sacramento River from the COS with elevated summer temperatures. Improvements in the PA relative to the COS include spring pulse flows and fall and winter redd maintenance flows. Benefits of these flows may include improvements in incubation of eggs, fry development and emergence, and downstream transport of juveniles. Migratory and rearing habitats in the middle Sacramento River are believed to be substantially degraded (National Marine Fisheries Service 2016b). This diminishes the ability of any CCV steelhead populations from the Sacramento Basin (e.g., mainstem Sacramento River, Clear Creek) to successfully rear in the Sacramento River or migrate to the Delta. Migratory and rearing PBFs of these habitats are not expected to change substantially under the PA.

### 2.8.6.3.3 American River

### 2.8.6.3.3.1 Status of CCV Steelhead Critical Habitat in the American River

The PBFs of critical habitat for lower American River CCV steelhead include freshwater spawning, freshwater rearing, and freshwater migration. There is a general consensus in the available literature suggesting that habitat for CCV steelhead in the American River is impaired (McEwan and Nelson 1991, California Department of Fish and Game 2001, Surface Water Resources Inc. 2001, Water Forum 2005, U.S. Bureau of Reclamation 2019). Of particular concern are warm water temperatures during embryo incubation, rearing, and migration, flow

fluctuations during embryo incubation and rearing, and limited flow-dependent habitat availability during rearing. All of these concerns are related to water management operations of the CVP.

## 2.8.6.3.3.2 Project Effects on CCV Steelhead Critical Habitat in the American River

CCV steelhead spawning (embryo incubation) and rearing PBFs in the American River are expected to be negatively affected by flow and water temperature conditions associated with the PA. For example, CCV steelhead spawning, egg incubation, and rearing habitat in the American River are negatively affected by flow fluctuations, which can result in redd dewatering and isolation, fry stranding, and juvenile isolation. Additionally, CCV steelhead egg incubation, juvenile rearing, and migratory habitat quality is expected to be reduced by the occurrence of warm water temperatures.

### 2.8.6.3.3.3 Assess Risk to CCV Steelhead Critical Habitat in the American River

Habitat within the American River below Nimbus Dam is believed to be historically unsuitability for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on the American River must be maintained by releases from Nimbus Dam and any level of degradation to the functioning of that habitat further limits its conservation value. Degraded habitat conditions associated with the COS including elevated summer rearing temperatures and spring flow fluctuations are not expected to significantly improve under the PA. Increased water demand is expected to result in considerable challenges to flow and water temperature management for American River aquatic resources below Nimbus Dam, and will likely exacerbate the negative habitat conditions already occurring in the river under present day water demands. Spawning and rearing habitat restoration under the PA may result in improved spawning substrates and side-channel rearing habitat but is unlikely substantially offset physical stressors to habitat (e.g., flow fluctuation, water temperature).

# 2.8.6.3.4 Sacramento San-Joaquin Delta

### 2.8.6.3.4.1 Status of CCV Steelhead Critical Habitat in the Delta

The PBFs of critical habitat for CCV steelhead in the Delta include freshwater and estuarine rearing and migration. Estuarine habitats for CCV steelhead have been substantially degraded [e.g., Sommer et al. (2007)] and evidence of this includes the collapse of the pelagic community in the Delta and dramatic habitat changes related to water quality, toxic algae blooms (e.g., Microcystis), and invasive species (e.g., the aquatic macrophyte Egeria densa).

## 2.8.6.3.4.2 Project Effects on CCV Steelhead Critical Habitat in the Delta

DCC gate operations, south Delta exports, and the agricultural barriers under the PA are expected to increase the frequency and duration of exposure of Clear Creek, mainstem Sacramento River, and American River steelhead to degraded central and south Delta habitats. Stanislaus River steelhead must migrate through severely impaired habitat in the San Joaquin River and south Delta channels to reach the ocean. South Delta exports and the agricultural barriers under the PA are also expected to increase the frequency and duration of exposure of Stanislaus River steelhead to lower suitability migration routes and rearing habitats within the central and south Delta. As described in detail in the supplemental Delta analysis in Section

2.5.5.11 (a) revisions to DCC operations in the final PA may reduce the routing of Sacramento-basin CCV steelhead into the interior Delta relative to the original PA and (b) revisions to loss thresholds associated with OMR management and commitments to review and technical assistance in the final PA provide some assurance that risks to both Sacramento-basin and San Joaquin-basin CCV steelhead will be conservatively managed and reduce effects relative to the original PA.

## 2.8.6.3.4.3 Assess Risk to Steelhead Critical Habitat in the Delta

Degraded estuarine habitat conditions associated with the COS including altered hydrology in migration habitat and poor rearing habitats are expected to worsen under the PA, although some effects are lessened (compared to the original PA) by the revisions to DCC operations and the loss thresholds associated with OMR management in the final PA. Restoration of Delta habitat under the PA will likely improve some rearing and migratory habitat quality, but is unlikely to substantially offset detrimental effects of operations and barriers on habitat associated with outflow and water quality. Under current usage practices, human population growth will place an increasing demand on limited water supplies, potentially exacerbating negative effects freshwater and estuarine rearing and migratory habitats within the domain of CCV steelhead.

### 2.8.6.3.5 Stanislaus River

# 2.8.6.3.5.1 Status of CCV Steelhead Critical Habitat in the Stanislaus River

CCV steelhead critical habitat on the Stanislaus River has been designated up to Goodwin Dam. The PBFs of critical habitat for Stanislaus River CCV steelhead include freshwater spawning, freshwater rearing, and freshwater migration. Although Stanislaus River water temperatures are generally suitable for spawning and rearing, during the smolt emigration life stage (January through June), CCV steelhead are exposed to water temperatures that would prohibit successfully completing transformation to the smolt stage. In addition, CCV steelhead spawning and rearing habitat on the Stanislaus River is affected by the limited occurrence of flows that are sufficient to carry out natural geomorphic processes. As such, sediment deposition on spawning habitats has decreased the availability of suitable spawning areas. Without strategic releases for geomorphic processes to manage fine sediment deposition in spawning gravels, spawning beds will be increasingly choked with sediment and unsuitable for spawning. The relatively low and uniform releases in the Stanislaus River negatively affect rearing habitat by reducing habitat complexity and decreasing connectivity with flood plains, areas proven to be high quality rearing habitats in the California Central Valley (Sommer et al. 2005).

# 2.8.6.3.5.2 Project Effects on CCV Steelhead Critical Habitat in the Stanislaus River

The factors affecting the current status of critical habitat for Stanislaus River CCV steelhead are all related to operations of the East Side Division of the CVP. Because operations of the East Side Division under the PA results in flow and temperature conditions generally consistent with past operations, the PA is expected to continue to compromise the conservation value of the spawning, freshwater rearing, and freshwater migration corridors PBFs of critical habitat within the Stanislaus River.

## 2.8.6.3.5.3 Assess Risk to Steelhead Critical Habitat in the Stanislaus River

Habitat within the Stanislaus River below Goodwin Dam is believed to be historically unsuitable for CCV steelhead spawning and rearing (Lindley et al. 2006). As a result, CCV steelhead habitat on the Stanislaus River must be maintained by releases from Goodwin Dam and any level of degradation to the functioning of that habitat further limits its conservation value. Degraded habitat conditions associated with the COS including elevated summer rearing temperatures, minimum flows, and dissolved oxygen standards are expected to continue under the PA. Proposed restoration of spawning and rearing habitat on the Stanislaus River is unlikely to substantially offset detrimental effects of operations under the PA.

# 2.8.6.3.6 San Joaquin River

# 2.8.6.3.6.1 Status of CCV Steelhead Critical Habitat in the San Joaquin River

CCV steelhead critical habitat on the San Joaquin River has been designated up to the confluence with the Merced River, however, the action area extends only up to the confluence with the Stanislaus River. Therefore, consistent with the analysis of effects to CCV steelhead in the San Joaquin River, the analysis in this section is limited in geographic extent to the San Joaquin River from the confluence with the Stanislaus River downstream past Vernalis to approximately Mossdale. Effects to designated critical habitat for CCV steelhead downstream of Mossdale are discussed in Section 2.5.5 Sacramento San Joaquin-Delta. The PBFs of critical habitat for CCV steelhead in the San Joaquin River (which may include individuals from the Merced River, Tuolumne River, and Stanislaus River) include freshwater rearing, and freshwater migration. CCV steelhead rearing and migratory habitat on the San Joaquin River is affected by channelization and the limited occurrence of flows that are sufficient to carry out natural geomorphic processes, leading to low habitat complexity and lack of connectivity to side channels or other shallow water habitat.

# 2.8.6.3.6.2 Project Effects on CCV Steelhead Critical Habitat in the San Joaquin River

As in the COS, operations under the PA do not allow for overbank flow to maintain floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility. Lack of flow fluctuation and channel forming flows has reduced habitat complexity, including undercut banks and side channels. Proposed operations will continue this degradation of rearing habitat conditions. Under proposed operations the freshwater migration corridors on this reach of the San Joaquin River will continue to require juvenile CCV steelhead to pass through a channelized river without the historical variety of habitats that allowed migrating salmonids to avoid high flows, avoid predators, and reach the ocean in a timely manner. CCV steelhead will often navigate these freshwater migration corridors at times that may not be optimal with respect to water temperature. In drier year types, flows at Vernalis under the PA are projected to be lower in April-June during the primary outmigration of CCV steelhead. PA flows in Jan and February are higher in wetter year types. Water temperatures at Vernalis are most unsuitable for rearing April and May, and unsuitable in March as well during drier years. Water temperatures at Vernalis are likely to be stressful to outmigrating CV spring-run Chinook salmon, or even serve as a barrier to migration, in May through September, and in April during drier years. Once implemented, the proposed floodplain habitat on the lower San Joaquin River is expected to provide localized improvements to rearing and migratory habitat.

# 2.8.6.3.6.3 Assess Risk to Steelhead Critical Habitat in the San Joaquin River

Degraded critical habitat conditions associated with the COS including limited habitat complexity, unsuitable water temperatures in late spring and summer, and sub-optimal spring flows are expected to continue under the PA. The extent to which proposed restoration of floodplain habitat on the Lower San Joaquin River can offset detrimental effects of operations under the PA will depend on yet-to-be-determined specifics of the project design such as spatial extent and the seasonal timing and frequency of inundation. In summary, The conservation value of the freshwater rearing and migration PBFs has been, and will continue to be, relatively poor under implementation of the PA.

# 2.8.6.4 Impact to the Critical Habitat at the Designation Level

At least five factors, when considered concurrently, suggest that implementation of the PA is expected to place CCV steelhead critical habitat at considerable risk. First, the status of CCV steelhead critical habitat is one characterized by severe degradation, including factors such as warm water temperatures and low flows, loss of natural river function and floodplain connectivity through levee construction, direct loss of floodplain and riparian habitat, loss of tidal wetland habitat, and poor water quality associated with agricultural, urban, and industrial land use. In general, much of the spawning, rearing, migratory, and estuarine habitat for CCV steelhead are considered as not properly functioning (National Marine Fisheries Service 2016b, Williams et al. 2016). Second, climate change is expected to further degrade the suitability of habitats in the Central Valley through increased water temperatures, increased frequency of drought conditions, and increased frequency of flood flows due to more precipitation falling as rain rather than snow (Lindley et al. 2007). Third, climate change is expected to further alter a degrade estuarine habitats through sea level rise and hydrological changes resulting in greater saline intrusion which in turn results in altering regional food webs. Fourth, under current practices, human population growth will place an increasing demand for limited water supplies, potentially exacerbating negative effects to spawning, rearing, migratory, and estuarine habitats. Lastly, the PA is expected to produce stressors every year through 2030 that will further compromise the conservation value of CCV steelhead spawning, rearing, and migratory habitats in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River, and further compromise the conservation value of migratory and estuarine habitats in the Delta for all extant CCV steelhead populations.

Based on the analysis of available evidence, NMFS concludes that the proposed action is likely to appreciably diminish the value of critical habitat for the conservation of CCV steelhead (Table 2.8.6-2).

Table 2.8.6-2. Reasoning and Decision-Making Steps for Analyzing the Proposed Action's Effects on Central Valley Steelhead Designated Critical Habitat. Application of Key Evidence is Provided in Italics. Each selected decision is shaded in gray. Acronyms and Abbreviations in the Action Column Refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Step	Apply the Available Evidence to Determine if	True/False	Action
	The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.  Available Evidence: Proposed action-related stressors adversely affecting the	True	End
A	environment include: (1) Sacramento River, Clear Creek, and Stanislaus River flow regulation disrupting natural river function and morphology; (2) warm water temperatures in the mainstem Sacramento River, Clear Creek, the American River, and the Stanislaus River; (3) low late-summer flows in Clear Creek and in the American and Stanislaus rivers; (4) modified Delta hydrology associated with export operations (e.g., pulling water towards the Federal and State pumping plants) and (5) Operation of south Delta agricultural barriers each year in three south Delta waterways.	False	Go to B
	Areas of designated critical habitat for CCV steelhead are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.	True	NLAA
В	Available Evidence: (1) Holding, spawning, rearing, and migratory habitats in the Sacramento River, Clear Creek, and the Stanislaus River will be exposed to regulated flows and their effects on river processes and morphology every year through 2030. (2) Each year through 2030, multiple habitat types including those supporting egg incubation and juvenile rearing in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River are expected to be exposed to water temperatures warmer than life stage-specific requirements. (3) Each year through 2030, rearing habitats in Clear Creek and in the American and Stanislaus rivers will be exposed to low flows particularly during the late-summer. (4) As water is moved from the north Delta and from the San Joaquin River to the Federal and State export facilities, each year through 2030, a large portion of emigrating steelhead will be entrained in low quality habitats characterized by an abundant predator community, an aquatic environment degraded by pesticides and contaminants, and increased risk of direct entrainment at the facilities. (5) Operation of south Delta agricultural barriers each year in three south Delta waterways resulting in additional predator structure, altered hydrodynamics, and impacted migratory corridors for CCV steelhead originating in the San Joaquin River basin.	False	Go to C
С	The quantity, quality, or availability of all constituent elements of CCV steelhead critical habitat are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action.  Available Evidence: (1) Loss of natural river function resulting from flow regulation has reduced the quality and quantity of rearing and migratory	True	NLAA

Step	Apply the Available Evidence to Determine if	True/False	Action
	habitats in the Sacramento River, Clear Creek, and the Stanislaus River. (2) Each year through 2030, the provision of water temperatures warmer than life stage-specific requirements will reduce the quantity and quality of steelhead egg incubation habitats in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River; the quality of rearing habitats in Clear Creek and the American River also will be reduced. (3) Low late-summer flows limit the availability of quality rearing habitat, including predator refuge areas. (4) Each year through 2030, the quality of rearing and migratory habitats is reduced by entraining juvenile steelhead into low quality habitats in the central and south Delta. (5) Operation of south Delta agricultural barriers each year in three south Delta waterways will increase structure for predators and diminish migratory corridor value of the South Delta waterways to CCV steelhead originating in the San Joaquin River basin.	False	Go to D
D	Any reductions in the quantity, quality, or availability of one or more constituent elements of CCV steelhead critical habitat are not likely to reduce the conservation value of the exposed area.	True	-
	Available Evidence: (1) flow regulation in the Sacramento River, Clear Creek, and Stanislaus River; (2) the provision of water temperatures warmer than life stage-specific requirements in Clear Creek, the mainstem Sacramento River, the American River, and the Stanislaus River; (3) low late-summer flows in Clear Creek, and the American and Stanislaus rivers; (4) the movement of water towards the Federal and State pumping plants; and (5) Operation of south Delta agricultural barriers each year in three south Delta waterways creates impediments to migration and increased predator habitat.	False	Go to E
E	Any reductions in the conservation value of the exposed area of CCV steelhead critical habitat are not likely to reduce the conservation value of the critical habitat designation.	True	No D/AD MOD
	Available Evidence: Because the conservation value of all freshwater habitat types (migratory, spawning/egg incubation, and rearing) necessary to complete the steelhead life cycle are expected to be reduced with implementation of the proposed Action, it is likely that the conservation value of the critical habitat designation will also be reduced.	False	D/AD MOD

# 2.8.7 Green Sturgeon

Listed as threatened April 7, 2006 (71 FR 17757 2006)

Detailed information regarding the federally listed sDPS green sturgeon, life history, and status of the species can be found in Section 2.2—Rangewide Status of the Species and Critical Habitat, and Appendix B.

# 2.8.7.1 Status of the Species and Environmental Baseline

The status of the species and critical habitat, as well as the environmental baseline, have been described at length in Sections 2.2 and 2.4, respectively. Although the VSP concept, as described in the Analytical Approach (Section 2.1), was developed for Pacific salmonids, the underlying parameters are general principles of conservation biology and can, therefore, be applied more

broadly. Here NMFS adopts the following four VSP parameters for analyzing sDPS green sturgeon viability: (1) abundance, (2) productivity, (3) spatial structure, and (4) diversity.

## 2.8.7.1.1 Southern DPS Green Sturgeon Abundance

The parameter of sDPS green sturgeon abundance, or the specific number of individuals in a particular life stage or total population number, is poorly understood. The ability to derive a reliable estimate of sDPS green sturgeon population abundance is particularly challenging given the sparsity of standardized monitoring information for any life stage of sDPS green sturgeon.

Historically, abundance and population trends of sDPS green sturgeon have been inferred in two ways; first by analyzing salvage numbers at the State and Federal fish salvage facilities, and second, by incidental catch of sDPS green sturgeon by the CDFW's white sturgeon sampling/tagging program. Both methods of estimating sDPS green sturgeon abundance are problematic due to extremely small sample sizes and potential biases in the data. Perhaps the most useful dataset for establishing and observing sDPS green sturgeon population trends presently available comes from spawning surveys that have been conducted utilizing Dual Frequency Identification Sonar (DIDSON) cameras in the mainstem Sacramento River since 2010. These surveys have recently been used to generate an adult sDPS green sturgeon abundance estimate of 2,106 (95 percent confidence interval [CI] = 1,246 –2,966; (Mora et al. 2018). This estimate does not include spawning adults in the lower Feather River where green sturgeon spawning was recently confirmed, however. Mora et al. (2018) also applied a conceptual demographic structure to the above adult population estimate and generated a subadult sDPS green sturgeon population estimate of 11,055 (95 percent CI = 6,540 – 15,571).

## 2.8.7.1.2 Green Sturgeon Productivity

The parameters of sDPS green sturgeon productivity, or population growth rate, and carrying capacity in the Sacramento River Basin are poorly understood. Larval count data from incidental bycatch in rotary screw traps collected since the mid-90s at RBDD and near the Glen Colusa Irrigation District diversion show enormous variability between years. The highest count and density on record was over 30 green sturgeon per acre-feet of water volume sampled at Red Bluff in 2016, an order of magnitude higher than other years (U. S. Fish and Wildlife Service 2016). In general, sDPS green sturgeon year class strength appears to be highly variable with overall abundance dependent upon a few successful spawning events (National Marine Fisheries Service 2010).

# 2.8.7.1.3 Green Sturgeon Spatial Structure

North American green sturgeon (made up of both nDPS and sDPS) are known to range from Baja California to the Bering Sea along the North American continental shelf. During the late summer and early fall, subadults and non-spawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett et al. 1991, Moser and Lindley 2007). Israel et al. (2009) found that green sturgeon within the Central Valley of California are sDPS green sturgeon. This green sturgeon DPS structure has also been corroborated by spawning site fidelity (National Marine Fisheries Service 2018g).

In waters inland from the Golden Gate Bridge in California, sDPS green sturgeon are known to range through the estuary and the Delta and upstream within the Sacramento, Feather, and Yuba

rivers. In the Yuba River, sDPS green sturgeon have been documented as far upstream as Daguerre Point Dam (Bergman et al. 2011). Migration past Daguerre Point Dam is not possible for sDPS green sturgeon, although potential spawning habitat upriver does exist. Similarly, sDPS green sturgeon have been observed by DWR staff at the upstream barrier to anadromy on the Feather River (Fish Barrier Dam) and potential spawning habitat also exists upriver of this barrier. On the Sacramento River, Keswick Dam, located at RM (river mile) 302, marks the highest point on the river accessible to sDPS green sturgeon, and it might be presumed that sDPS green sturgeon would utilize habitat to this point. However, USFWS sampled for larvae in 2012 at RM 267 and at RM 292 and no larvae were caught at these locations; habitat usage could not be confirmed any further upriver than the confluence with Ink's Creek (RM 264), which was a confirmed spawning site in 2011 (Poytress et al. 2012). However, Heublein et al. (2009) detected adults as far upstream as RM 280 near Cow Creek, suggesting that their spawning range may extend farther upstream than previously documented. The upstream extent of their spawning range lies somewhere below ACID Dam (RM 298), as that dam and associated fish ladder presumably impede passage for sDPS green sturgeon in the Sacramento River. It is uncertain, however, if sDPS green sturgeon spawning habitat exists in cooler water reaches near ACID Dam, which could allow spawning to shift upstream in response to climate change effects. Adams et al. (2007) summarizes information that suggests sDPS green sturgeon may have been distributed above the locations of present-day dams on the Sacramento and Feather rivers. (Mora et al. 2009) analyzed and characterized known sDPS green sturgeon habitat and used that characterization to identify historic sDPS green sturgeon habitat within the Sacramento River and San Joaquin River basins that are currently blocked by dams. This study concluded that about 9 percent of historically available habitat now blocked by impassible dams, was likely of high quality for spawning.

Mora (2016a) demonstrated that sDPS green sturgeon spawning sites are concentrated into very few locations, finding that in the Sacramento River just 3 sites accounted for over 50 percent of the sDPS green sturgeon spawning activity documented in June of 2010, 2011, and 2012. This is a critical point with regards to the application of the spatial structure VSP parameter, which is largely concerned with the spawning habitat spatial structure, as well as other life history stages. A high concentration of individuals in just a few spawning sites, is more vulnerable to increased extinction risk due to stochastic events.

Southern DPS green sturgeon have been documented in areas of the lower San Joaquin River; (Radtke 1966) reported catching green sturgeon in tidal portions of the San Joaquin River at the Santa Clara Shoals. Anglers have also reported catching sDPS green sturgeon at various locations within the San Joaquin River basin upstream of the tidally-influenced Delta. Further, one adult sDPS green sturgeon was confirmed in the Stanislaus River (a tributary to the San Joaquin River) in 2017 (Anderson et al. 2018). With no historical or current evidence of spawning, however, it is believed that sDPS green sturgeon only use portions of the San Joaquin River and its tributaries for rearing.

In summary, current available information indicates that the spatial structure of sDPS green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River, and also breeds opportunistically in the Feather River and Yuba River. Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent extirpation from upstream

spawning reaches of the San Joaquin River narrows the habitat usage by the species, leaving little buffer to impacts to the species.

## 2.8.7.1.4 Green Sturgeon Diversity

Diversity, as defined in (McElhany et al. 2000), includes genetic traits such as DNA sequence variation, and other traits that are influenced by both genetics and the environment, such as ocean behavior, age at maturity, and fecundity. Variation is important to the viability of a species for several reasons. First, it allows a species to utilize a wider array of environments than they could without it. Second, diversity protects a species from short term spatial and temporal changes in the environment by increasing the likelihood that at least some individuals will have traits that allow them to persist in spite of changing environmental conditions. Third, genetic diversity provides the raw material necessary for the species to have a chance to adapt to changing environmental conditions over the long term.

While it is recognized that diversity is crucial to the viability of a species in general, it is unclear how well sDPS green sturgeon display these diversity traits and if there is sufficient diversity to buffer against long term extinction risk. In general, a larger number of populations and number of individuals within those populations should offer increased diversity and greater chance of long term viability. The diversity of sDPS green sturgeon is probably low given current abundance estimates, and limited spatial structure. Also, because human alteration of the environment is so pervasive in the California Central Valley, basic diversity principles such as run timing and behavior are likely negatively influenced through mechanisms such as diminished springtime flow rates as water is impounded behind dams.

## 2.8.7.1.5 Southern DPS Green Sturgeon Viability Summary

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of primary spawning sites into a limited section of the river. The risk of extinction is believed to be moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the accuracy of population abundance indices (National Marine Fisheries Service 2018g). Viable status is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe. The best available scientific information does not indicate that the extinction risk facing sDPS green sturgeon is negligible over a long term (~100 year) time horizon; therefore, the sDPS is not currently viable. To support this statement, the population viability analysis (PVA) that was done for sDPS green sturgeon in relation to stranding events (Thomas et al. 2014) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, it was alarming to note that over a 50-year time period the sDPS green sturgeon population declined under all scenarios where stranding events were recurrent over the lifespan of an sDPS green sturgeon.

Although the population structure of North American green sturgeon is still being refined (i.e., number of DPS), it is currently believed that sDPS green sturgeon are comprised of only one population. Lindley et al. (2007), in discussing winter-run Chinook salmon, stated that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over

the long run. This concern applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon directly, it could be said that sDPS green sturgeon face a high extinction risk. However, NMFS concludes, upon weighing all available information (and lack thereof), the extinction risk is moderate. Additional information about sDPS green sturgeon is critical, especially with regards to a robust abundance estimate, habitat usage, a greater understanding of their biology, and further information about their habitat needs.

Reclamation established a "without-action" scenario as part of the BA's Environmental Baseline to isolate and define potential effects of the proposed action apart from effects of non-proposed action. NMFS considers the without-action scenario to represent effects related to the existence of CVP and SWP facilities. The without-action scenario provides context for how these facilities have shaped the habitat conditions for species and critical habitat in the action area. Under Reclamation's "without action" scenario, there would be both positive and negative effects on the status of sDPS green sturgeon. Higher flows in winter and spring could have both positive and negative effects on green sturgeon. Benefits of higher flows include lower water temperatures, increased dissolved oxygen, increased habitat complexity, more rearing habitat, more refuge habitat, increased availability of prey, less predation risk, less entrainment risk, lower potential for pathogens and disease, lower concentrations of toxic contaminants, and emigration cues. Reduced flows could have negative impacts on spawning adults, eggs, and larvae, juveniles and sub-adults, resulting in increased temperature-dependent mortality of eggs, reduced juveniles growth rate and higher mortality of the juveniles, and a reduced population abundance.

However, as discussed previously, the Environmental Baseline also includes the effects of past and current operations of the CVP and SWP, and the additional effects of habitat restoration, predation from invasives, water quality, and other effects on species from Federal, State, and private actions to inform the current condition of sDPS green sturgeon. As discussed above, the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years.

# 2.8.7.2 Summary of Proposed Action Effects

Detailed descriptions regarding the exposure, response, and risk of sDPS green sturgeon to stressors associated with the PA are presented in Section 2.5, Effects of the Action. Major effects to sDPS green sturgeon from the PA include: temperature impacts to eggs and larvae in the Sacramento River, upstream passage impacts above ACID, and migratory impacts to juvenile and adults in the lower Sacramento River and Delta. The PA effects are limited to spawning adults and early life stages on the Sacramento River and water temperature that may be less favorable for these life stages in downstream spawning reaches below RBDD (RM 243). Ambient water temperature modelled under the PA may exceed suitable levels (≥17°C or 62°F) during the critical egg fertilization and incubation period in the majority of years at the downstream extent of the putative spawning reach near Hamilton City (RM 205). Suitability of downstream spawning areas may be further restricted due to increased water temperatures in critically dry water year types, which may become more frequent under different climate change scenarios.

Prior to 2012, seasonal closure of RBDD limited sDPS green sturgeon spawning to habitats that were likely unsuitable for egg incubation in some years. With permanent decommissioning of

RBDD, sDPS green sturgeon presumably have access to suitable spawning and incubation areas on the Sacramento River under all conditions (e.g., droughts). ACID dam, approximately 5 miles below Keswick Dam (RM 302), remains a potential passage barrier to spawning green sturgeon on the Sacramento River. The percentage of the sDPS green sturgeon spawning run that would utilize the uppermost 5 miles of the Sacramento River between ACID dam and Keswick Dam is unknown, but is currently estimated to be small based on the lack of acoustic tag detections in this reach. However, the proportion of sDPS green sturgeon spawning impeded by the ACID Dam may increase with potential spawning habitat expansion, or warmer water releases at Keswick Dam. Additional migration barriers to sDPS green sturgeon on the Sacramento River include the DCC gates and South Delta Agricultural Barriers. Very few sDPS green sturgeon are observed or detected in the south Delta, and without the context of an accurate abundance estimate, the effects of the agricultural barriers in the Delta, along with South Delta operations to sDPS green sturgeon remain uncertain. Revisions to the salmonid loss thresholds associated with OMR Management are expected to reduce the export footprint under the final PA compared to the original PA and potentially result in reduced effects to sDPS green sturgeon. Revisions to the DCC operations in the final PA may lead to more DCC closures, which may enhance the potential for migratory delays for sDPS green sturgeon but may reduce the routing of juveniles into the interior Delta. Conservation measures in the PA include large-scale habitat restoration in the Delta and fish screen improvements on small water diversions. The effect of these actions is uncertain without description of specific project location and design or background information on green sturgeon responses to restoration. Implementation of conservation measures like Delta habitat restoration, however, is generally expected to improve the likelihood for recovery and survival for sDPS green sturgeon.

### Assess Risk to the Population

As stated Section 2.1.3.1.2, Analytical Approach to Southern Distinct Population Segment of Green Sturgeon, NMFS believes that the concepts and viability parameters developed to address viable populations of salmonids in McElhany et al. (2000) can also be applied to the sDPS of green sturgeon due to the general similarity in life cycle and freshwater/ocean use. The VSP concept is an approach to evaluate the population viability of sDPS green sturgeon under the PA and a way to determine the extinction risk of the DPS based on changes to the VSP parameters of abundance, productivity, spatial structure, and diversity. Viability of the population and extinction risk of the DPS relate to the likelihood of both the survival and recovery of the DPS. As described in Section 2.5 Effects of the Action, the PA will impose conditions in the Sacramento River and Delta that will affect sDPS green sturgeon in a number of ways that are expected to reduce the fitness of these individuals. Based on the change in fitness of these individuals, NMFS assesses whether the collective changes constitute a change in the VSP parameters and whether that change will affect the sDPS green sturgeon population.

Table 2.8.7-1. Summary of proposed action-related Effects on sDPS green sturgeon organized by division component.

Upper Sacramento /Shasta Division	Upper Sacramento /Shasta Division	Division
Drought and Dry Year Actions	Temperature Modeling Platform	Action Component
Water Temperature	Water Temperature	Stressor
Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Life Stage (location)
April - July (May 15 - July), May - August (May 15 - August)	April - July (May 15 = July), May - August (May 15 - August)	Life Stage Timing (Work Window Intersection)
Drought and Dry Year Actions have been identified for winter-run Chinook salmon as a way to mitigate for temperatures higher than 53.5°F which result in reduced egg survival. These actions are	Improved modeling should help reduce the uncertainty related to temperature forecasting which could minimize temperature dependent mortality for winter-run Chinook salmon and to a lesser extent the other ESUs or DPSs spawning in the Sacramento River.	Individual Response and Rationale of Effect
Benef icial: Low	Benef icial: Low	Severi ty of Stress or/Lev el of Benefi t
Large	Large	Proportion of Population Exposed
Low	Medium	Frequenc y of Exposure
Medium	Medium	Magnitu de of Effect
High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	Weight of Evidence
Increased reproductive success; increased survival probability	Increased reproductive success; increased survival probability	Probable Change in Fitness

Upper Sacramento /Shasta Division	Division
Drafting of Temperature Management Plan Using Conservative Forecasts	Action Component
Water Temperature	Stressor
Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Life Stage (location)
April - July (May 15 - July), May - August (May 15 - August)	Life Stage Timing (Work Window Intersection)
expected to benefit the sDPS green sturgeon in the Sacramento River as well but to a lesser degree.  Using conservative forecasts to inform the development of the Temperature Management Plan is expected to reduce the frequency of there being temperatures higher than 53.5°F during the winter-run Chinook salmon spawning and incubation period. It is expected to provide an indirect benefit to the sDPS green sturgeon that spawn in the Sacramento River as well.	Individual Response and Rationale of Effect
Benef icial: Low	Severi ty of Stress or/Lev el of Benefi t
Large	Proportion of Population Exposed
High	Frequenc y of Exposure
Medium	Magnitu de of Effect
High: Supported by multiple scientific and technical publication s that include quantitative models specific to the region and species.	Weight of Evidence
Increased reproductive success; increased survival probability	Probable Change in Fitness

Upper Sacramento/ Shasta Division	Upper Sacramento /Shasta Division	Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division	Division
Spring Pulse Flow	Delta Smelt Summer-Fall Habitat	Tier 1 (Shasta Cold Water Pool Mgmt.)	Tier 4 (Shasta Cold Water Pool Mgmt.)	Action Component
Altered Flow, Passage Impediments/ Barriers to Migration	Water Temperature	Water Temperature	Water Temperature	Stressor
Adults (Middle, Lower Sacramento River)	Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Life Stage (location)
March - July (March - May 15)	April - July (May 15 - July), May - August (May 15 - August)	April - July (May 15 - July), May - August (May 15 - August)	April - July (May 15 - July), May - August (May 15 - August)	Life Stage Timing (Work Window Intersection)
For adults increased flows may facilitate swimming past barriers, or they may merely serve as a cue for migration. High flows are also correlated with lower temperatures that	PA temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	PA temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	PA temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Individual Response and Rationale of Effect
Benefi cial: Mediu m	Sublet hal	Sublet hal	Sublet hal, Lethal	Severi ty of Stress or/Lev el of Benefi t
Large	Large	Medium (31% of days >63.5°F at Hamilton City)	Large (74% of days >63.5°F), Medium (8% of days >71.5)	Proportion of Population Exposed
Medium (<75% of years)	Low	Medium (45 - 68% of years)	Low (5 - 7% of years)	Frequenc y of Exposure
Medium	Medium	Medium	Medium, High	Magnitu de of Effect
Medium: Correlation of flow and migration supported by multiple scientific and technical publications.	Low	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Weight of Evidence
Improved reproductive success	Decreased reproductive success; decreased survival probability	Reduced reproductive success	Reduced reproductive success, Reduced survival probability	Probable Change in Fitness

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Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division		Division
Tier 2 (Shasta Cold Water Pool Mgmt.)	Spring Mgmt. of Spawning Locations		Action Component
Water Temperature	Water Temperature		Stressor
Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Adults (Upper Sacramento River)		Life Stage (location)
April - July (May 15 - July), May - August (May 15 - August)	March - July (April - May)		Life Stage Timing (Work Window Intersection)
PA temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Lower temperatures may benefit pre-spawn females by ensuring that eggs are not damaged and normal embryo development occurs after spawning	benefit females migrating upriver by ensuring that eggs are not damaged before spawning.	Individual Response and Rationale of Effect
Sublet hal	Benefi cial: Mediu m		Severi ty of Stress or/Lev el of Benefi t
Medium (42% of days >63.5°F)	Large		Proportion of Population Exposed
Low - Medium (17 - 35% of years)	Uncertain		Frequenc y of Exposure
Low	Medium		Magnitu de of Effect
Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Low: A number of scientific and technical publications have suggested a relationship between temperature and salmonid spawning but a direct effect is still unknown. Effects to green sturgeon are more uncertain.		Weight of Evidence
Reduced reproductive success	Improved reproductive success		Probable Change in Fitness

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	Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division	Division
	Juvenile Trap and Haul (tier 4 intervention)	Wilkins Slough intakes (Cold water pool mgmt.)	Tier 3 (Shasta Cold Water Pool Mgmt.)	Action Component
	Monitoring, Maintenance, Research Studies, etc. (minimization for Water Temperatures)	Passage Impediments/Barri ers, Flow Conditions, Loss of Riparian Habitat and Instream Cover	Water Temperature	Stressor
	Juveniles (Upper Sacramento River)	Adults, Juveniles (Middle Sacramento River)	Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Life Stage (location)
	May - August (Uncertain)	March - September (Construction: June - September), May - October (Construction: June - October)	April - July (May 15 - July), May - August (May 15 - August)	Life Stage Timing (Work Window Intersection)
Depending on	Uncertain. Framework programmatic action component to be implemented in Tier 4 years when river conditions are unsuitable for juvenile winter- run Chinook salmon rearing.	Framework programmatic action component, construction activities are not described. NMFS assumes that construction would occur during an appropriate in- water work window and include BMPs and minimization measures to limit potential effects to species.	PA temperature ranges from temps associated with abnormal development of eggs and larvae (Sublethal) to decrease in egg survival (Lethal) in lab studies.	Individual Response and Rationale of Effect
	Sublet hal	Sublet hal	Sublet hal	Severi ty of Stress or/Lev el of Benefi
	Uncertain	Small	Medium (67% of days >63.5°F)	Proportion of Population Exposed
	Low (7% of years)	Uncertain	Low (7 - 15% of years)	Frequenc y of Exposure
	Low	Low	Low	Magnitu de of Effect
	Low: (Programmat ic action component) very little information available as to how this action component would be implemented	Low: (uncertain) very little information available as to how this action component would be implemented (construction ).	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Weight of Evidence
	Reduced survival probability	Reduced survival probability	Reduced reproductive success	Probable Change in Fitness

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Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division		Division
Winter Minimum flows	Small Screen Program (Spawning/reari ng habitat restoration)	Fall and Winter Refill and Redd Maintenance		Action Component
Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function	Construction or installation of fish screens on water diversions. Passage Impediments/Barri ers, Flow Conditions, Loss of Riparian Habitat and Instream Cover	Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function		Stressor
Juveniles (Upper Sacramento River)	Adults, Juveniles (Middle Sacramento River)	Juveniles (Upper Sacramento River)		Life Stage (location)
May - August (little overlap with December - February operations)	March - September (Uncertain), May - October (Uncertain)	May - August (little overlap with October/Novem ber operations)		Life Stage Timing (Work Window Intersection)
Decreased flows may reduce access to channel margin and side channel rearing habitats	Framework programmatic action component. Construction activities are not described but assumed construction effects related to installation of fish screens include: changes in flow, stranding (installation of coffer darns), and handling.	Decreased flows may reduce access to channel margin and side channel rearing habitats	timing and location of trap and haul operations, juvenile green sturgeon could also be collected and returned to the river or relocated.	Individual Response and Rationale of Effect
Minor	Sublet hal	Minor		Severi ty of Stress or/Lev el of Benefi t
Uncertain	Low	Uncertain		Proportion of Population Exposed
Uncertain	Low (Uncertai n)	Uncertain		Frequenc y of Exposure
Low	Low	Low		Magnitu de of Effect
Low: minimal information on flow and habitat requirements for juvenile	Low: (Programmat ic action component) very little information available as to how this action component would be implemented (construction ).	Low: minimal information on flow and habitat requirements for juvenile green sturgeon	or as to its effects.	Weight of Evidence
Reduced growth rate and survival probability	Reduced reproductive success, Reduced survival probability	Reduced growth rate and survival probability		Probable Change in Fitness

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Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division		Division
habitat (Spawning/reari ng habitat restoration)	Spawning Gravel Injection (Spawning/reari ng habitat restoration)	Wilkins Slough intakes (Cold water pool mgmt.)		Action Component
vegetation, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Spawning Habitat Availability, Loss of Riparian Habitat and Instream Cover, Physical Habitat Alteration	Entrainment/Impin gement at water diversions		Stressor
(Middle Sacramento River)	Adults, Juveniles (Upper Sacramento River)	Juveniles (Middle Sacramento River)		Life Stage (location)
September (Uncertain), May - October (Uncertain)	March - September (Uncertain), May - August (Uncertain)	May - October		Life Stage Timing (Work Window Intersection)
quality and quantity. Framework programmatic action component. no description of timing, location or extent of effects.	Increased habitat quality and quantity. Framework programmatic action component. Programmatic action component, no description of timing, location or extent of effects.	Framework programmatic action component, operation is assumed to comply with NMFS and CDFW fish screening guidance.		Individual Response and Rationale of Effect
cial: Low	Benefi cial: Low (Uncer tain)	Low (Benef icial)		Severi ty of Stress or/Lev el of Benefi t
	Low	Small		Proportion of Population Exposed
(Permane nt)	High (Permane nt)	Low		Frequenc y of Exposure
	Low	Low		Magnitu de of Effect
(Programmat ic action component) very little information available as to how or where this action component would be	Low: (Programmat ic action component) very little information available as to how this action component would be implemented or the extent of its effects.	Low: (uncertain) very little information available as to how this action component would be implemented or its effects when operated.	green sturgeon	Weight of Evidence
growth rate	Increased reproductive success and survival probability	Increased survival probability		Probable Change in Fitness

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Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division	Upper Sacramento/ Shasta Division		Division
Operation of a Shasta Dam Raise	Adult rescue (tier 4 intervention)	Small Screen Program (Spawning/reari ng habitat restoration)		Action Component
NA	Passage Impediments/Barri etts, Entrainment/Impin gement at water diversions	Operation of new or repaired fish screens on water diversions. Entrainment/Impin gement at water diversions		Stressor
N A	Adults (Middle Sacramento River)	Adults, Juveniles (Middle Sacramento River)		Life Stage (location)
NA	March - September (Uncertain)	March - September (Uncertain), May - October (Uncertain)		Life Stage Timing (Work Window Intersection)
None. Reclamation has committed to no change in operations with the inclusion of a	Uncertain. Framework programmatic action component. Increased stress and mortality related to capture and handling. Minimization measure intended to increase relative survival of adult salmonids entrained in water diversions (e.g., Yolo and Sutter Bypasses).	Framework programmatic action component. Construction activities are not described but operation is assumed to comply with NMFS and CDFW fish screening guidance.		Individual Response and Rationale of Effect
NA	Benefi cial: Low	Benefi cial: Low		Severi ty of Stress or/Lev el of Benefi t
NA	Uncertain (Intervention measure may not apply to green sturgeon?)	Uncertain		Proportion of Population Exposed
NA	Uncertain (Low: tier 4 years = 7% of all years)	High (Permane nt)		Frequenc y of Exposure
NA	Low	Low		Magnitu de of Effect
NA	Low: (Programmat ic action component) very little information available as to how this action component would be implemented or as to its effects.	Low: (Programmat ic action component) very little information available as to how this action component would be implemented (construction ) or its effects when operated.	implemented or the extent of its effects.	Weight of Evidence
NA	Increased reproductive success, Increased survival probability	Increased survival probability (NMFS/CDF W fish screening criteria 5% loss)		Probable Change in Fitness

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Delta	Delta	Upper Sacramento/ Shasta Division		Division
CVP/SWP South Delta Exports	CVP/SWP South Delta Exports	Battle Creek Restoration (Cold water pool mgmt.)		Action Component
Entrainment and loss at the South Delta export facilities	Altered hydrodynamics in South Delta/ routing	AN		Stressor
Juveniles - Sacramento River -Delta	Juveniles - Sacramento River - Delta	None (Species not present in Battle Creek)		Life Stage (location)
Year round presence	Year round presence	AN		Life Stage Timing (Work Window Intersection)
Entrainment of juvenile green sturgeon into the fish salvage facilities, unknown vulnerability to	Mortality or decreases in condition due to migratory delays in response to altered hydrodynamics in channels of the South Delta. Loss of appropriate migratory cues. Delays increase transit time and exposure to predators, poor water quality, and contaminants.	Covered under 2005 NMFS/USFWS Biological Opinions	Shasta Dam raise such that there will be no change in the frequency of meeting management criteria nor will there be any change in the timing and volume of releases.	Individual Response and Rationale of Effect
Sublet hal to Lethal	Sublet hal to Lethal	AN		Severi ty of Stress or/Lev el of Benefi t
small	Medium -	AN		Proportion of Population Exposed
high - year round exports	High- year- round exports	AN		Frequenc y of Exposure
Medium - sustained high frequency exposure on small proportio n of	Medium	AN		Magnitu de of Effect
High Medium - studies have evaluated the effect of screening facilities, and	Medium to High - effects of hydrodynami cs well studied and modelled. Effects of hydrodynami cs on green sturgeon migrations in South Delta less certain.	NA		Weight of Evidence
Reduced survival; lesser effect in final PA due to revised loss thresholds associated	Reduced survival, reduced growth; likely lesser effect in final PA due to revised loss thresholds associated with OMR management.	None (included in the baseline)		Probable Change in Fitness

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Delta	Delta		Division
DCC Gate operations -	DCC Gate operations -		Action Component
Routing	Routing		Stressor
Juveniles - Sacramento River - Delta	Adults - Sacramento River - Delta		Life Stage (location)
Year round presence	Year round presence		Life Stage Timing (Work Window Intersection)
Movement into the Mokelumne River system from the Sacramento River increased routing distance to the western Delta	Movement into and through the Mokelumne River system, increased transit distance to/from western Delta	predation or loss through louvers.	Individual Response and Rationale of Effect
Minor	Minor		Severi ty of Stress or/Lev el of Benefi t
High - all juvenile green sturgeon emigrate downstream in the Sacramento River. DCC gates are open from mid-June through the end of October. Closed Feb - mid-May	High - Sacramento River basin is only known spawning area, DCC adjacent to main migratory route for adults		Proportion of Population Exposed
high- gates are open every year during the summer allowing re-routing into Delta interior.	high - gates open every year during the summer, closed during winter		Frequenc y of Exposure
Medium	Medium	populatio n	Magnitu de of Effect
Low - There is little information regarding green sturgeon migratory movements through the DCC -	Low - There is little information regarding green sturgeon migratory movements through the DCC -	predation on green sturgeon, but not specifically related to loss as well as survival through at the facilities	Weight of Evidence
Minimal negative change in fitness, potential exposure to lower quality rearing habitat; lesser effect in final PA due to revised DCC operations in December-January.	Delayed migration, possible reduction of spawning success	with OMR management.	Probable Change in Fitness

Delta	Delta	Division
DCC Gate operations -	DCC Gate operations -	Action Component
Altered Hydrodynamics downstream of DCC location	Transit times	Stressor
Juveniles - Sacramento River - Delta	Juveniles - Sacramento River -Delta	Life Stage (location)
Year round presence	Year round presence	Life Stage Timing (Work Window Intersection)
When gates are closed, riverine reach of Sacramento extends farther downstream, less tidal influence, faster transit times. When gates are opened, more routing into Delta interior	Increased migration times to western Delta	Individual Response and Rationale of Effect
Minor	Minor	Severi ty of Stress or/Lev el of Benefi
High- opening of gates reduces the proportion of riverine reaches adjacent to the DCC location; closing of gates extends the riverine reaches farther downstream. Entire summer and fall season of emigration occurs with gates in open position.	High - all juvenile green sturgeon emigrate downstream in the Sacramento River. DCC gates are open from mid-June through the end of October. Closed Feb - mid-May	Proportion of Population Exposed
high - gates are operated every year - open during the summer, closed during the Feb - mid-May period.	High - gates are operated every year - open during the summer, closed during the Feb - mid-May period.	Frequenc y of Exposure
Mcdium	Medium	Magnitu de of Effect
Low - There is little information regarding green sturgeon migratory movements through the DCC - Green sturgeon juveniles rear within the waters of the Delta for up to 3 years.	Low - There is little information regarding green sturgeon migratory movements through the DCC - Green sturgeon juveniles rear within the waters of the Delta for up to 3 years.	Weight of Evidence
Minimal negative change in fitness, potential exposure to lower quality rearing habitat; lesser effect in final PA due to revised DCC operations in December-January.	Minimal negative change in fitness, potential exposure to lower quality rearing habitat; lesser effect in final PA due to revised DCC operations in December-January.	Probable Change in Fitness

Delta	Delta	Division
South Delta Agricultural Barriers	South Delta Agricultural Barriers	Action Component
transit times	transit times	Stressor
Adults - South Delta	Juveniles - South Delta	Life Stage (location)
Year round presence	Year round presence	Life Stage Timing (Work Window Intersection)
Delayed migration and increased transit times with potential for increased mortality due to increased exposure to poor water quality and high water temperatures	Delayed migration and increased transit times with potential for increased mortality due to increased exposure to poor water quality and high water temperatures	Individual Response and Rationale of Effect
Sublet hal to Lethal	Sublet hal to Lethal	Severi ty of Stress or/Lev el of Benefi t
Small	Small	Proportion of Population Exposed
High	High	Frequenc y of Exposure
Medium - installatio n of barriers occurs every year from April/Ma y through the end of Novembe r and blocks off free passage through the three main channels of the	Medium - installatio n of barriers occurs every year from April/Ma y through the end of Novembe r and blocks off free passage through the three main channels of the South Delta	Magnitu de of Effect
Medium - several studies have indicated that the barriers increase transit time through the South Delta and increase exposure to ambient water quality conditions	Medium- several studies have indicated that the barriers increase transit time through the South Delta and increase exposure to ambient water quality conditions	Weight of Evidence
Reduced survival	Reduced survival	Probable Change in Fitness

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Division		Delta	Delta
Action Component		CCF aquatic weed control	CCF aquatic weed control
Stressor		exposure to herbicides	exposure to herbicides
Life Stage (location)		Adults - Sacramento River - Delta	Juveniles - Sacramento River - Delta
Life Stage Timing (Work Window Intersection)		Year round presence	Year round presence
Individual Response and Rationale of Effect		adverse physiological effects (i.e., reduced growth and survival), due to exposure to harmful compounds in the water	Adverse physiological effects (i.e., reduced growth and survival), and increased vulnerability to predation due to exposure to harmful compounds in the water
Severi ty of Stress or/Lev el of Benefi		Sublet hal to Lethal	Sublet hal to Lethal
Proportion of Population Exposed		Small	Small
Frequenc y of Exposure		High	High
Magnitu de of Effect	South Delta	Medium	Medium
Weight of Evidence		Medium- several ecotoxicolog ical studies on the herbicides to be used. The majority of the studies are on surrogate fish species.	Medium- several ecotoxicolog ical studies on the herbicides to be used. The majority of the studies are on surrogate fish species.
Probable Change in Fitness		Reduced survival	Reduced survival

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Delta	Delta	Division
North Bay Aqueduct	DCC Gate operations -	Action Component
Entrainment and impingement onto fish screens	Increased entrainment and loss at the South Delta Exports facilities	Stressor
Juveniles - Sacramento River -Delta	Juveniles - Sacramento River -Delta	Life Stage (location)
Year round presence	Year round presence	Life Stage Timing (Work Window Intersection)
Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Increased mortality of entrained fish at the CVP and SWP fish salvage facilities	Individual Response and Rationale of Effect
Minor	Sublet hal to Lethal	Severi ty of Stress or/Lev el of Benefi t
Small	Small to Medium	Proportion of Population Exposed
high	ндн	Frequenc y of Exposure
Low- screens are designed for delta smelt criteria, few green sturgeon expected to be present at screen location	Low- sustained populatio n effects on a small to medium proportio n of the populatio n present in the Delta	Magnitu de of Effect
High - monitoring has few observations of green sturgeon at this location, multiple studies regarding efficiency of positive barrier fish screens	Medium - numerous studies have evaluated the potential risk to salmonids entering the Delta interior and becoming vulnerable to entrainment at the fish salvage facilities. Unknown applicability to green sturgeon	Weight of Evidence
Minimal negative change in fitness	Reduced survival; lesser effect in final PA due to revised DCC operations in December-January and revised loss thresholds.	Probable Change in Fitness

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Delta	Delta	Delta	Division
North Bay Aqueduct	North Bay Aqueduct	North Bay Aqueduct	Action Component
Impingement/ capture during aquatic weed cleaning	Entrainment during sediment cleaning	Routing	Stressor
Juveniles - Sacramento River -Delta	Juveniles - Sacramento River -Delta	Juveniles - Sacramento River -Delta	Life Stage (location)
Year round presence	Year round presence	Year round presence	Life Stage Timing (Work Window Intersection)
Injury or death due to impingement, capture by grappling hooks during weed removal	Injury or death due to entrainment into dredge or impingement onto fish screens	Increased migration times to western Delta	Individual Response and Rationale of Effect
Sublet hal to Lethal	Sublet hal to Lethal	Minor	Severi ty of Stress or/Lev el of Benefi
Small	Small	Small	Proportion of Population Exposed
Low. Aquatic weeds removed infrequent ly	Low. Sediment removed infrequent ly	hìgh	Frequenc y of Exposure
Low - fish unlikely to be in area of screens during cleaning	Low-fish unlikely to be in area of screens during cleaning	Low- very small proportio n of populatio n will be present in Barker Slough, low impacts of diversion volumes on hydrodyn amics	Magnitu de of Effect
Low. No reports or studies available	Low. No reports or studies available	Low - There is little information regarding green sturgeon migratory movements through the Delta - Green sturgeon juveniles rear within the waters of the Delta for up to 3 years.	Weight of Evidence
Minimal change in fitness	Minimal change in fitness	Minimal negative change in fitness	Probable Change in Fitness

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Delta	Delta	Delta	Division
2.5.6.8.1.1.4 Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Predator removal studies	CCWD Rock Slough water diversions	Action Component
Temporary change in water flow/water quality (20 days Oct-May, 60 days June-Sept)	capture in sampling gear	routing	Stressor
Adults and juveniles may migrate through the area on their way to spawning grounds or as outmigrating juveniles.	Juveniles - Sacramento River -Delta	Juveniles - Sacramento River -Delta	Life Stage (location)
SMSCG ops from October through May coincides with the upstream migration of green sturgeon and late winter and spring downstream juvenile migration. During summer ops, juvenile and adult green sturgeon may be present.	Year round presence	Year round presence	Life Stage Timing (Work Window Intersection)
During the annual 70 to 80 days of periodic operation, individual adult green sturgeon may be delayed in their spawning migration from a few hours to several days. Green sturgeon are less affected since they spawn in deep turbulent sections of the upper reaches of the Sacramento River.	Increased vulnerability to injury and predation due to entanglement/entr apment in sampling gear	Delayed migration and increased transit times	Individual Response and Rationale of Effect
Minor	Sublet hal to Lethal	Minor	Severi ty of Stress or/Lev el of Benefi
Low	Small	Small	Proportion of Population Exposed
Low frequency for adult migration period (<10% of days)	Low	high - pumping through the Rock Slough diversion occurs every year	Frequenc y of Exposure
Low	Low - infrequent sampling over two to three years of study	Low- small numbers of fish are likely to be in the vicinity of the fish screens and intake	Magnitu de of Effect
Low-data on green sturgeon migration and rearing in Suisun Marsh is low	Medium - Several reports from previous predator removal studies, literature on sampling methods.	Low. No reports or studies available regarding green sturgeon presence in front of the fish screens	Weight of Evidence
Minimal	Reduced survival, potential injury from gear or handling	Minimal change in fitness	Probable Change in Fitness

	- 8	
Delta	Delta	Division
Sacramento Deep Water Ship Channel Food Study	2.5.6.8.1.1.4 North Delta Food Subsidies/ Colusa Basin Drain	Action Component
Altered hydrodynamics and migration routing in the Ship Channel	Temporary water quality (July/Sept)	Stressor
Adults and Juveniles	Adult green sturgeon migrate through the area on their way to spawning grounds or as outmigrating juveniles	Life Stage (location)
likely to be exposed to potential increase in contaminants.  Potential increase in water temp from ag ditch water (not described in ROC on LTO BA).  Year-round presence in Delta	During agricultural drainage into the N Delta, juvenile and adult green	Life Stage Timing (Work Window Intersection)
drainage from Colusa Basin Drain to Cache Slough during July and September. Exposure would likely be limited and short-term. Given the short time period, significant effects are not expected. Potential delays and false attraction to the opening and closing of the boat locks, potential diversion from Sacramento River into Deepwater ship channel when boat locks are open, exposure to reduced water quality in Port of Sacramento and Deepwater ship channel, increased	May be temporarily exposed to increased contaminants	Individual Response and Rationale of Effect
Sublet hal to Lethal	Minor	Severi ty of Stress or/Lev el of Benefi
Low	Low	Proportion of Population Exposed
during the July through Septembe r period	Low initially study will last a few years, conducted	Frequenc y of Exposure
Slough	Low nutrient suppleme ntation in area of	Magnitu de of Effect
nutrient supplementat ion on green sturgeon sturgeon sturgeon on sturgeon on sturgeon on sturgeon migration behavior and use within the Sacramento Deepwater ship channel, and Port of Sacramento	Low - little information available regarding the effects of proposed	Weight of Evidence
Reduced fitness	Minimal	Probable Change in Fitness

Delta	Delta	Division
Fall Delta Smelt Habitat Operations	Water Transfer Window Extension	Action Component
Temporary change in water flow/water quality	Low fall flows	Stressor
Adults and Juveniles	Adults and Juveniles – Sacramento River - Delta	Life Stage (location)
Year-round presence in Delta	Year -round presence	Life Stage Timing (Work Window Intersection)
Potential changes in Delta hydrodynamics due to export reductions and increased Delta inflow from upstream may reduce entrainment at the export facilities and create better foraging opportunities, induce downstream migrations	Elevated flows in October or November due to additional water being transferred may decrease transit times to the Delta in riverine reaches	Individual Response and Rationale of Effect shipping traffic and ship strikes
Benefi cial: Low	Benefi cial: Low	Severi ty of Stress or/Lev el of Benefi t
Medium	Medium	Proportion of Population Exposed
Medium (Septemb er and October of above normal and wet water year types)	Medium	Frequenc y of Exposure
Low – adult and juvenile green sturgeon already can move to find suitable foraging areas in the Delta	Low	Magnitu de of Effect
Low – little information available on green sturgeon regional movements in the Delta and their foraging behavior.	Low, very little information available on green sturgeon migratory behavior in relation to flow levels.	Weight of Evidence
Minimal benefit	Minimal benefit	Probable Change in Fitness

Eastside/San Joaquin	Division
n PA Conditions	Action Component
Reductions in spring flows and associated temperatures, water quality, water depth, contaminant concentrations, wetland function.	Stressor
Adults and juveniles San Joaquin River between the confluence with the Stanislaus River and Mossdale	Life Stage (location)
Adults and juveniles present year round, but responses to flow and temperature-related stressors most likely during winter and spring, when the PA has the most limiting effect on flows.	Life Stage Timing (Work Window Intersection)
Potential for decreased survival or growth due to increased exposure to poor water quality and high water temperatures	Individual Response and Rationale of Effect
Sublet hal	Severi ty of Stress or/Lev el of Benefi t
Small	Proportion of Population Exposed
Low	Frequenc y of Exposure
Low	Magnitu de of Effect
Low information available on green sturgeon use of the lower San Joaquin River between Mossdale and the confluence of the Stanislaus River	Weight of Evidence
Reduced survival or reduced growth	Probable Change in Fitness

### sDPS Green Sturgeon Abundance

As it is for salmonids, the three key attributes of the abundance VSP parameter require that the relative size of a spawning population be large enough to: (1) have a high probability of surviving environmental variability, (2) allow compensatory process to provide resilience from environmental and anthropogenic disturbance, and (3) maintain its genetic diversity (McElhany et al. 2000). Although, the ability to derive a reliable estimate of sDPS green sturgeon population abundance is challenging, the current, best estimate of annual abundance of sDPS green sturgeon adults is 2,106 [95 percent CI = 1,246 –2,966 (Mora 2016a)]. To evaluate the effects of the PA on the abundance VSP parameter of sDPS green sturgeon, NMFS assesses if the probable change in fitness attributed to the effects of a stressor would result in "reduced survival" or "reduced reproductive success" (identified in Table 2.8.7-1) for a significant proportion of adults. Changes to the juvenile and sub-adult populations are also considered; however, those affects are reflected in the assessment of the productivity VSP parameter, because juveniles and sub-adults are not part of the effective population and changes to the fitness of these life stages are not considered in the assessment of the abundance VSP parameter.

NMFS expects primarily low and medium magnitude impacts to sDPS green sturgeon from the PA such that only a small portion of the population are likely to experience mortality or substantial injury, and elements of the PA that affect medium to large portion of the population will be of lower severity (i.e., behavioral). Examples of these impacts include reduced reproductive success for individuals spawning in lower reaches of the Sacramento River due to elevated water temperatures and migration delays due to the DCC and South Delta agricultural barriers. Presumably, adult sDPS green sturgeon exposed to elevated water temperatures would adjust spawning to somewhere in the nearly 100-mile stretch of progressively cooler spawning habitat upstream of Hamilton City. Thus, temperature effects are only expected to temporarily impact a small number of individuals and are unlikely to constitute a reduction in the effective population size of the sDPS. Migration delays are likely to reduce the fitness and eventual spawning success of exposed adults, which, would constitute a reduction in the effective population size of the sDPS. In rare instances, some adults could be permanently re-routed into the South Delta and experience reduced survival. However, migration delays in the Delta are only expected to affect a small portion of the adult population for a relatively short duration (i.e., temporary reduction in reproductive success). Thus, effects of the PA are unlikely to significantly reduce the abundance VSP parameter of sDPS green sturgeon.

### Southern DPS Green Sturgeon Productivity

The productivity VSP parameter for sDPS green sturgeon, is described by the key attributes of a population's ability to reproduce itself, and the survival of early life stages. For salmonids, the productivity VSP parameter is also described by a population's resilience to the influence of hatchery-produced spawners, but since sDPS green sturgeon is not supplemented by a hatchery, this attribute does not factor into the consideration of productivity VSP parameter. Based on the attributes remaining for sDPS green sturgeon, the common metric used to assess the productivity VSP parameter is the population growth rate (or decline). Lindley et al. (2007) further identified that the population growth rate (10-year trend estimated from the slope of log-transformed estimated run size), must not show a decline in order for a salmonid population to be considered at a low risk of extinction. If the population is experiencing a decline within last two generations to annual run size  $\leq 500$  spawners, or run size  $\geq 500$  but declining at  $\geq 10$  percent per year, that

population would be considered at high risk of extinction. Direct measurements of productivity, such as larval count data at the RBDD rotary screw traps is highly variable and because of potential high mortality of the larval life stage and slow maturation of the species, trend detection dependent upon these types of data sets is extremely difficult. Given the limitations of using the metric of population growth rate (based on trend estimates) to assess changes in the sDPS green sturgeon population's productivity VSP parameter, we examine the relative effect of actions that would impact the juvenile population. Specifically, if the probable change in fitness attributed to the effects of a stressor would result in "reduced survival" or "reduced growth" (identified in Tables 2-259 and 2-260) for a significant proportion of the juvenile population (≥ 10 percent) in a given year, that would be considered a reduction of the productivity VSP parameter of the population.

NMFS expects that the PA will have multiple impacts that will affect the abundance and fitness of juvenile sDPS green sturgeon, but these impacts are unlikely to affect the productivity VSP parameter of sDPS. Most of the effects are expected to have a low to medium magnitude of impact to exposed sDPS green sturgeon individuals such that they are unlikely to result in mortality or substantial injury. As described in Section 2.5.1.2 Operation Effects, under the PA, Delta operations and agricultural barriers continue to alter the natural hydrograph of the Delta and its waterways. This impacts the productivity VSP parameter of sDPS green sturgeon (i.e., growth and recruitment) because of potentially increased travel times of juveniles and exposure to degraded habitats. The PA also includes operations of the existing South Delta fish salvage facilities and increased reverse flows in the South Delta compared to current conditions, which will result in additional negative effects such as direct mortality of early life stages at and around the South Delta fish salvage facilities (e.g., entrainment, impingement). Based on extremely low sampling numbers and reports, only a small proportion of the juvenile population is believed to experience significant migration delays or entrainment into the South Delta. This suggests proposed Delta operations and barriers will only have a small effect on sDPS green sturgeon recruitment and production, which may be further reduced by the revisions to the loss thresholds associated with OMR management in the final PA. The PA also includes restoration of Delta habitat, which has the potential to benefit the productivity VSP parameter of sDPS green sturgeon and offset impacts associated with South Delta operations and agricultural barriers.

Other actions associated with the PA that are considered to have impacts on the productivity of sDPS green sturgeon include water temperature and flow management in the upper Sacramento River. These actions are expected to affect sDPS green sturgeon productivity by reducing fitness of a small to medium proportion of larvae and juveniles that rear near the downstream extent of the spawning reach. As described above, it is presumed that during low flow conditions, spawning and rearing of the majority of the sDPS green sturgeon population would occur in more suitable habitats upriver and offset potential poor spawning production of downriver reaches.

Revisions to the Cold Water Pool Management section of the final PA include the addition of Section 4.10.1.3.3 Upper Sacramento Performance Metrics. The objective of these performance metrics is to ensure that the performance of the PA operations for temperature management falls within the modeled range, and shows a tendency towards performing at least as well as the distribution produced by the simulation modeling of winter-run Chinook salmon temperature dependent mortality. This revision affects the green sturgeon analysis by increasing the certainty that the analysis more accurately characterizes exposure and risk to green sturgeon due to the PA

operations. With this change, we consider our previous analysis of the modeled outcomes of temperature management – which is based on the central tendency to capture the most likely conditions – to be a more accurate characterization of projected and expected operations. The results described in Section 2.5.2.3.3.1 Summer Cold Water Pool Management do not change quantitatively due to the revisions included in the final PA, as this commitment to assess cold water management does not affect the modeling results used to characterize the exposure of the species to the stressor of increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type.

We do consider the project components that are intended to offer as much protection as practicable in drought or extreme conditions, including the process for development of an annual temperature management plan, the use of conservative forecasts, protection of the third cohort of winter-run Chinook salmon after two consecutive years of poor survival, and specific "at the ready" actions for drought and dry years. The temperature management plan may reduce the likelihood of exceeding the temperature target, which is used in the characterization of exposure to increased temperatures in the analysis. The conservation measures intended to protect the third cohort of winter-run Chinook salmon after two consecutive years of poor survival may allow opportunities for actions to be implemented to reduce temperature-related effects on green sturgeon despite the probability of year types that may occur. Finally, NMFS expects a reduction in extreme effects on the species throughout extended drought due to the Drought and Dry Year Actions. We note that potential benefit of a toolkit of actions to be taken in drought conditions, and the process by which early warnings of drought conditions may allow for clear and swift development of a drought contingency plan, but we also consider that managing a listed species in a crisis-management scenario is not a long-term strategy to achieving viability.

Based on the available information, NMFS assumes the effect of water temperature and flow management in the upper Sacramento River, Delta operations, agricultural barriers, and restoration will not significantly reduce sDPS green sturgeon production. However, annual recruitment monitoring does not exist (and is not included in the PA) and our understanding of the effect of the PA on sDPS green sturgeon production may change with improved measures of production.

### Southern DPS Green Sturgeon Spatial Structure

The spatial structure parameter of a VSP is determined by the availability, diversity, and utilization of properly functioning habitats and the connections between such habitats. Southern DPS green sturgeon are primarily limited in spatial structure as they comprise only one population that spawns in the Sacramento River but also spawns opportunistically in the Feather and Yuba rivers. The listing highlighted this as a major threat to the species, and to reduce this risk, consistent spawning is needed in at least one additional location outside the mainstem Sacramento River. Given the relative lack of habitat available to sDPS green sturgeon in the baseline, there could be considerable impact to the spatial structure VSP parameter if it is further reduced. Stressors, attributed to the PA, that would increase or further limit access to available habitats would be expected to affect the spatial structure VSP parameter.

As described in Section 2.5, and given the level of exposure to sDPS green sturgeon to the agricultural barriers and South Delta exports, the PA could result in further limiting the species ability to move between habitats. However, these elements of the PA are not anticipated to impact a large proportion of the juvenile or adult population with our current understanding of

sDPS green sturgeon habitat usage and migration. In Section 2.5.1.2.1 Increased Upstream Temperature, temperatures under the PA were above the suitable threshold for sDPS green sturgeon spawning and incubation during certain months of a percentage of years. These temperature-related effects are not expected to significantly impact sDPS green sturgeon spatial structure, however, because under normal conditions suitable temperatures for spawning and incubation are available in a relatively large reach of spawning habitat on the Sacramento River. Therefore, the PA would not result in Delta or upstream conditions in the Sacramento River that would diminish the spatial structure VSP parameter in a way that is expected to limit the appropriate exchange of spawners or the expansion of a population into underutilized habitat.

### Southern DPS Green Sturgeon Diversity

The diversity VSP parameter comprises the three key attributes of (1) variation in traits such as run timing, age structure, size, fecundity, morphology, behavior and genetic characteristics; (2) resilient gene flow among populations that is limited; and (3) maintenance of ecological variation (McElhany et al. 2000). Diversity is related to population viability because it allows a species to exploit a wider array of environments, protects against short-term spatial and temporal changes in the environment, and provides the raw material for surviving long-term environmental changes. At this time, we do not have methods to directly measure diversity or compare or assess changes to the present and historical levels of diversity. However, stressors, attributed to the PA that would limit the variation in sDPS green sturgeon traits, or that would select for a particular behavior or life history, would be expected to influence the diversity VSP parameter of the sDPS green sturgeon population.

Overall, the PA is not expected to exert any additional selective pressures on sDPS green sturgeon and the diversity VSP parameter of the population is expected to remain unchanged. Given the higher temperature tolerances of the early life stage of sDPS green sturgeon compared to salmonids (and the recent decommissioning of RBDD in 2012), appropriate conditions for spawning and incubation are present year-round in accessible reaches of the Sacramento River. This allows for the potential for multiple spawning runs of sDPS green sturgeon in the Sacramento River in most years. Therefore, the PA is not expected to alter the diversity VSP parameter of the sDPS green sturgeon population.

### 2.8.7.3 Assess the Risk to DPS

Given that the entire sDPS green sturgeon is represented by a single population, the discussion points above apply equally to both the population level analysis and that of the DPS as a whole. As described in the VSP analysis above, effects of the PA are unlikely to significantly reduce the abundance and productivity, diminish the spatial structure, or alter the diversity of sDPS green sturgeon. Thus, as summarized above and described in Section 2.5 Effects of the Action on Species, the PA is expected to have a negative effect on the population, but it will not appreciably reduce the survival or viability of sDPS green sturgeon. The sDPS green sturgeon recovery plan (National Marine Fisheries Service 2018g) describes criteria for determining sDPS green sturgeon population recovery and alleviation of threats. Demographic recovery criteria are population metrics that if achieved demonstrate population recovery and alleviation of threats. Threat-based recovery criteria involve actions that would result in population recovery and are as follows:

- Access to spawning habitat is improved through barrier removal or modification in the Sacramento, Feather, and/or Yuba rivers such that successful spawning occurs annually in at least two rivers.
- Volitional passage is provided for adult green sturgeon through the Yolo and Sutter bypasses.
- Water temperature and flows are provided in spawning habitat such that juvenile recruitment is documented annually.
- Adult contaminant levels are below levels that are identified as limiting population maintenance and growth.
- Operation guidelines and/or fish screens are applied to water diversions in mainstem Sacramento, Feather, and Yuba rivers and San Francisco Bay Delta Estuary such that early life stage entrainment is below a level that limits juvenile recruitment.
- Take of adults and subadults through poaching and state, federal and tribal fisheries is minimal and does not limit population persistence and growth.

The PA does not include actions on the Feather or Yuba rivers that would support an alternate sDPS green sturgeon spawning river (criteria number 1 above). Passage through the Yolo and Sutter bypasses are also not included in the PA (criteria number 2). Factors directly affecting adult contaminant levels and take are not included in the PA (criteria numbers 4 and 6). For criteria that are associated with the PA, the influence on recovery is uncertain. Water temperatures and flows necessary for sDPS green sturgeon recruitment are poorly understood. Southern DPS green sturgeon larval abundance and juvenile recruitment both appear to be related to elevated flows in the Sacramento River, although specific operational targets to support spawning and recruitment (e.g., Sacramento River temperature compliance point) have not been developed (criteria number 3). Conversely, recruitment of sDPS green sturgeon in critically dry years is likely poor, but without knowledge of the specific mechanism for recruitment failure (e.g., decline of riverine or estuarine habitat) the effect of the PA on recruitment is unclear. The proposed small screen program may reduce early life stage entrainment of sDPS green sturgeon and increase juvenile recruitment if implemented strategically or on a large scale (criteria number 5). With our current understanding of sDPS green sturgeon, the PA does not include actions that specifically preclude recovery.

After reviewing and analyzing the current status of the listed species, the environmental baseline, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of the Southern DPS of North American green sturgeon (Table 2.8.7-2).

Table 2.8.7-2. Reasoning and decision-making steps for analyzing the effects of the proposed action on green sturgeon. Darker shade identifies the conclusion at each step of decision-making. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and not likely/likely to jeopardize (NLJ/LJ).

Step	Apply the Available Evidence to Determine if	True/False	Action
A	The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.	True	End
A	Available Evidence: The PA will produce multiple stressors that will adversely affect green sturgeon including, but not limited to: impingement and entrainment, and effects related to reduced Delta flows.	False	Go to
D	Listed individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action.	True	NLAA
В	Available Evidence: A medium proportion of individuals from the sDPS population are expected to be exposed to impacts from operations in the PA throughout the year over multiple years.	False	Go to
	Listed individuals are not likely to respond upon being	True	NLAA
C	exposed to one or more of the stressors produced by the proposed action.  Available Evidence: Multiple stressors, including but not limited to passage barriers and operations will rise to a level of effect that will engender a response from exposed individuals.	False	Go to
	Any responses are not likely to constitute "take" or reduce	True	NLAA
D	the fitness of the individuals that have been exposed.  Available Evidence: Multiple stressors, including but not limited to those associated with agricultural barriers and operations are expected to result in a reduction of overall fitness of individuals which could rise to the level of "take."	False	Go to E
	Any reductions in individual fitness are not likely to	True	NLJ
E	reduce the viability of the populations those individuals represent.  Available Evidence: The overall reduction in fitness of individuals caused by the PA is expected to reduce some of the parameters describing a viable population; however, those reductions would not constitute a reduction in viability of the population or an increase in extinction risk for the species.	False	Go to F
F		True	NLJ

Step	Apply the Available Evidence to Determine if	True/False	Action
	Any reductions in the viability of the exposed populations are not likely to reduce the viability of the species.	False	LJ
	Available Evidence: Not Applicable		

### 2.8.8 Green Sturgeon Critical Habitat

• Critical habitat designated October 9, 2009 (74 FR 52300)

### 2.8.8.1 Status

As described in Section 2.6, critical habitat for sDPS green sturgeon consists of several physical and biological features occurring in freshwater, riverine, estuarine, and marine habitats that are essential for the conservation of the species. Designated critical habitat for sDPS green sturgeon is composed of seven PBFs that are shared among different life stages across the different habitat types. All of those PBFs are considered necessary habitat features that facilitate successful spawning, rearing, and migration. Therefore, we have evaluated the effect of the PA in terms of its effect on the PBFs present in the freshwater and estuarine habitats for rearing juveniles and migrating juveniles, adults, and sub-adults.

As described in Section 2.2 Rangewide Status of the Species and Critical Habitat, many of the PBFs of sDPS green sturgeon designated critical habitat are currently degraded or impaired and provide limited high quality habitat. Features that lessen the quality of migratory corridors and rearing habitat for juveniles include unscreened or inadequately screened diversions, altered flows in the Delta, and the presence of contaminants in sediment. Although the current conditions of sDPS green sturgeon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in both the Sacramento/San Joaquin River watersheds and the Delta are considered to have high intrinsic value for the conservation of the species.

### Summary of Proposed Action Effects on Designated Critical Habitat

Detailed descriptions regarding the impacts to designated critical habitat caused by stressors associated with the PA are presented in Section 2.6, Effects of the Action to Critical Habitat. The PA-related effects to sDPS green sturgeon designated critical habitat have been further separated by life-stage specific habitat type and assessed by the effects on the PBFs found therein. Much like the effects to the species, the effects to sDPS green sturgeon designated critical habitat are summarized in Table 2.8.8-1.

### Habitat for Spawning Adults, Incubation of Eggs, and Rearing Larvae and Juveniles

With the PA, NMFS does not expect an appreciable reduction in the PBFs of sDPS green sturgeon critical habitat used for spawning of adults and rearing for larvae and juveniles. Specifically, the PA is not expected to adversely impact the PBFs of these habitats, including: substrate type or size, water flow, and water quality. The PA will have periods of higher temperature in lower reaches of spawning habitat, but suitable spawning and incubation temperature is available in accessible upstream areas. The PA also does not describe any specific

in-water activity that would appreciably disturb, contaminate, remove, or otherwise degrade the substrate type or size within the known spawning and freshwater rearing range for sDPS green sturgeon in the Sacramento River. Based on related entries in Table 2.8.8-1, the combined effects of the PA, environmental baseline, and cumulative effects are not expected to negatively affect these PBFs.

### Freshwater and Estuarine Rearing and Migratory Corridors for Juveniles and Adults

The PA is expected to result in some degradation to the migratory PBFs for juvenile and adult life stages in the lower Sacramento River and Delta. The effects of combined exports present an entrainment issue that could delay migration, expose individuals to poor rearing habitat, or decrease survival through entrainment into the fish salvage facilities themselves. Southern DPS green sturgeon may be exposed to these effects year-round and for the duration of the PA with effects increasing in magnitude the closer to the export facilities the fish are located. Export effects may be reduced, compared to the original PA, by the revisions to loss thresholds associated with OMR management in the final PA. Likewise, DCC gate operations and the operation of the South Delta agricultural barriers enhance the potential to delay movement and migratory behavior in the channels of the South Delta. Juvenile and adult sDPS green sturgeon may be trapped behind the barriers after construction/operation for varying periods of time. Revisions to the DCC operations in the final PA may lead to more closures, which may enhance the potential for migratory delays for sDPS green sturgeon but may reduce the routing of juveniles into the interior Delta. While the PBFs in the designated freshwater riverine and estuarine habitat are degraded by the PA, they still function in providing access from the upper river habitat to the marine environment.

Table 2.8.8-1. Summary of PA related effects on sDPS green sturgeon critical habitat.

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Shasta	Shasta	Shasta	Shasta	Division
Spawning Gravel Injection (2.5.2.3.2.1)	Seasonal Operations (2.5.2.1)	Summer Cold Water Management (2.5.2.1.3)	Summer Cold Water Management (2.5.2.1.3)	Action Component
Upper Middle Sacramento River (Cottonwood Creek to Hamilton City)	Middle Sacramento River	Middle Sacramento River	Upper Middle Sacramento River (Cottonwood Creek to Hamilton City)	Location of Effect
Substrate Type or Size	Water Flow, Food Resources, Sediment Quality, Depth	Water Quality	Water Quality	PBFs Affected
Framework programmatic action component.  As part of adaptive management Reclamation would implement spawning gravel, injection project(s) in the action area. This action component could increase the quantity and quality of available substrate suitable for spawning.	Water Flow PBF can determine access to the quantity and quality of the other PBFs (Food Resources, Sediment Quality, and Depth) in the freshwater rearing habitat. Small increases in flow onto the bypasses (Yolo and Sutter) would provide a small increase to freshwater rearing habitat for juvenile green sturgeon.	PA temperatures in excess of 66.2°F (7% of days) are sub optimal for green sturgeon rearing, leading to reduced growth.	PA temperatures in excess of 63.5°F (39% of days) can lead to Sublethal abnormal development of eggs and larvae. Temperatures higher than 71.5°F (<1% of days) would cause a decrease in egg survival.	Response and Rationale of Effect
Low (Uncertain)	Low	Low	Medium	Magnitude of Effect
Low: (Programmatic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Medium: Supported by scientific and technical publications that include modeled flow conditions specific to the action area.	High: Supported by multiple scientific and technical publications that include lab studies to verify temperature thresholds for optimal growth.	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Weight of Evidence
Increased quantity/quality of spawning Substrate Type or Size PBF	Increased Water Flow PBF, increased access to Food Resources, Sediment Quality, and Depth PBFs	Decreased Water Quality PBF	Decreased Water Quality PBF	Probable Change in PBF Supporting the Life History Needs of the Species

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Division	Shasta	Shasta	Shasta	Delta
Action Component	Side-Channel habitat (2.5.2.3.2.2)	Small Screen Program (2.5.2.3.2.3)	Lower Intakes near Wilkins Slough (2.5.2.3.1.2)	SWP and CVP South Delta Operations
Location of Effect	Upper Middle Sacramento River (Cottonwood Creek to Hamilton City)	Middle Sacramento River	Middle Sacramento River	Freshwater Riverine Habitat for Juveniles and Sub-adults: Lower Sacramento, San Joaquin, and American Rivers and Delta [Freeport to Golden Gate (GG) Bridge]
PBFs Affected	Water Flow, Substrate Type or Size	Migratory Corridors	Migratory Corridors	water flow, migratory corridors
Response and Rationale of Effect	Framework programmatic action component.  As part of adaptive management Reclamation would implement sidechannel habitat restoration project(s) in the action area. This action component could increase access to areas suitable for spawning which includes increased flow to those areas as well as the quantity and quality spawning substrate.	Framework programmatic action component. Construction activities (?) are not described but design and diversion operation is assumed to comply with NMFS and CDFW fish screening guidance.	Framework programmatic action component. Construction activities (?) are not described but design and diversion operation is assumed to comply with NMFS and CDFW fish screening guidance.	Operations of the CVP and SWP exports alter the flows in the channels of the South Delta, degrading the functioning of the channels as a migratory corridor to reach the western Delta and SF Bay. Effects of the altered flow conditions increases the exposure to entrainment into the export facilities.
Magnitude of Effect	Low (Uncertain)	Low (Uncertain)	Low (Uncertain)	Medium - Extended duration of residency in the Delta increases the frequency of exposure to altered migratory corridors for green sturgeon, and increases the vulnerability to entrainment into the export facilities.
Weight of Evidence	Low: (Programmatic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Low: (Programmatic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Low: (Programmatic action component) very little information available as to how or where this action component would be implemented or the extent of its effects.	Medium - Numerous peer reviewed studies on salmonids have shown how altered hydrodynamics in the channels surrounding the exports are impacting migratory behavior. However, there are no studies directed at green sturgeon, thus uncertainty as to the magnitude of impacts.
Probable Change in PBF Supporting the Life History Needs of the Species	Increased Water Flow PBF (spatial), increased quantity/quality of spawning Substrate Type or Size PBF	Increased access to Migratory Corridors PBF	Increased access to Migratory Corridors PBF	Reduction in the quality of the migratory corridor; lesser effect in final PA due to revised loss thresholds associated with OMR management.

Division	Delta	Delta
Action Component	Water transfers	DCC Gate operations, NBA Operations, CCWD Rock Slough Operations
Location of Effect	Freshwater Riverine Habitat for Juveniles and Sub-adults: Lower Sacramento, San Joaquin, and American Rivers and Delta (Freeport to GG Bridge)	Freshwater Riverine Habitat for Juveniles and Sub-adults: Lower Sacramento, San Joaquin, and American Rivers and Delta (Freeport to GG Bridge)
PBFs Affected	Water flow, water quality, migratory corridor, food resources	water flow, migratory corridors
Response and Rationale of Effect	Increased flow may aid downstream migration of juveniles and adults during the extended water transfer window (July I to November 30) and improve water quality parameters (dissolved oxygen, temperature). Improved flows and water quality may improve primary and secondary productivity, which enhances the forage base for green sturgeon.	Operations of the DCC gate and exports at the NBA and CCWD may alter the migratory corridors used by green sturgeon. Alternative routes may have better, less, or equal quality habitat for green sturgeon. Extended residence time of green sturgeon within the Delta indicates that multiple waterways and habitats will be utilized during their time in the Delta.
Magnitude of Effect	Low - volumes of transfers may not be enough to sustain changes in flow or water quality for very long. Dependent on frequency and volumes of released transfer water from upstream reservoirs.	Low-export volumes at the NBA and CCWD are relatively small and any migratory delays are small compared to the time green sturgeon spend in the Delta; rerouting of green sturgeon through the DCC into the Delta interior may not impact survival of green sturgeon over the duration of their residency in the Delta.
Weight of Evidence	Medium - numerous studies and reports regarding water quality requirements for green sturgeon, less so for flows. Modeling is generally too coarse to get fine scale resolution of hydrodynamic changes based on the size of releases.	Low- few studies exist that track the migratory behavior through the Delta for juvenile or adult lifestages, and those studies do not examine fine scale movements or use of Delta habitats.
Probable Change in PBF Supporting the Life History Needs of the Species	Temporary improvement in flows and water quality as a result of the releases of transfer water during the extended transfer window. Better water quality and higher flows may improve food resources for green sturgeon.	Unknown which Delta habitats are preferred by each life stage category and how they are utilized. Impacts of migratory delays or re-routing are unknown with certainty, but will be increased due to operations. Revisions to the DCC operations in the final PA may lead to more closures, which may enhance the potential for migratory delays for sDPS green sturgeon but may reduce the routing of juveniles into the interior Delta.

T	<u> </u>	<u> </u>	
Division	Delta	Delta	Delta
Action Component	South Delta Agricultural Barriers	2.5.6.8.1.1.1 Fall Delta Smelt Habitat (X2)	2.5.6.8.1.1.3 Sacramento Deep Water Ship Channel Food Study
Location of Effect	Freshwater Riverine Habitat for Juveniles and Sub-adults: Lower Sacramento, San Joaquin, and American Rivers and Delta (Freeport to GG Bridge)	Suisun Marsh and vicinity	SDWSC downstream to Sacramento River confluence
PBFs Affected	water flow, water quality, migratory corridors	water flow, water quality, migratory corridor	flow, water quality, and migration corridors free of passage impediments
Response and Rationale of Effect	Operations of the barriers will create physical barriers, which will impede the free movement of both adult and juvenile green sturgeon within the waterways of the affected South Delta waterways. It is unlikely that fish will pass over the barrier crests, and passage through the tidally operated culverts will be restricted to entry from the downstream side of the barrier during flood tides for almost all of the irrigation season when the barriers are operated. Fish trapped by the barriers will be exposed to reduced water quality, and potentially a diminishment of food resources above the barriers.	The action may result in changes to low salinity location, flow volume, and water temperatures. A small change in low salinity zone (X2) location would likely result in minimal effects to salmonid and green sturgeon critical habitats. Water temperatures may be altered have an effect on prey abundance, water quality, and migration corridor. Short-term changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG are not expected to significantly change habitat availability or suitability for rearing green sturgeon.	Reconnecting the SDWSC to the Sacramento River will allow flow through the ship channel which will improve conditions (water temp, flow), but will impact habitat downstream by mobilizing contaminants and other water quality parameters.
Magnitude of Effect	Low - The frequency of use of the South Delta channels by adult and juvenile green sturgeon is unknown, thus the impacts of the severely reduced quality of the migratory corridors may not affect a substantial proportion of the population.	Low	Low
Weight of Evidence	Low- few reports exist that track the migratory behavior through the South Delta for juvenile or adult green sturgeon lifestage, and those reports do not examine fine scale movements or use of South Delta habitats.	Low	Low
Probable Change in PBF Supporting the Life History Needs of the Species	Reduction in the function of the Freshwater Riverine Habitat for water quality, migratory corridors, adequate water flows, and potentially food resources	Low	Low

		<u> </u>	V
Eastside/San Joaquin River	Delta	Delta	Division
PA conditions	2.5.6.8.1.1.4 Suisun Marsh Roaring River Distribution System Food Subsidy Studies	2.5.6.8.1.1.4 North Delta Food Subsidies / Colusa Basin Drain and Suisun Marsh Roaring River Distribution System Food Subsidy Studies	Action Component
San Joaquin River between the confluence with the Stanislaus River and Mossdale	Suisun Marsh	North Delta	Location of Effect
Food resources, water flow and water quality, and migratory corridor.	Green sturgeon PBFs in estuarine areas: food resources, water flow, water quality, migratory corridor, water depth, and sediment quality.	food resources, water quality.	PBFs Affected
Channelized river limits availability of varied rearing and migratory habitat.	Fish passage will be affected by the operation of the SMSCG. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 70-80 days of annual operation. However, these changes in water flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Short-term changes in tidal flow are not expected to significantly change habitat availability or suitability	Water quality would be temporarily affected by the Colusa Basin drainage into the N Delta, which would temporarily expose fish to agricultural drainage water potentially containing contaminants (pesticides, nutrients) during two months of the year. Exposure would be limited and temporary and would not likely affect survival.	Response and Rationale of Effect
Low	Low	Low	Magnitude of Effect
Low	Low	Low	Weight of Evidence
Reduced quality necessary for normal behavior, growth, and survival.	Low	Low	Probable Change in PBF Supporting the Life History Needs of the Species

### 2.8.8.2 Impact to the Critical Habitat of the Species at the Designation Level

Individual PBFs are diminished to varying degrees as a result of the PA. However, the magnitude of these impacts is generally low within the context of the broader designated critical habitat as a whole. Further, conservation measures (e.g., habitat restoration, small screen program) may partially restore PBFs in some areas. Therefore, considering the relative size and scale of the exposed areas, the context of these areas within the broader designated critical habitat as a whole, and conservation measures proposed in the PA, critical habitat and associated PBFs are still expected to function at a level necessary to support conservation of the species.

After reviewing and analyzing the current status of the critical habitat, the environmental baseline, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to appreciably diminish the value of the critical habitat for the conservation of the Southern DPS of North American green sturgeon.

Table 2.8.8-2. Reasoning and decision-making steps for analyzing the effects of the proposed action on designated critical habitat for sDPS green sturgeon. Darker shade identifies the conclusion at each step of decision-making. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Step	Apply the Available Evidence to Determine if	True/False	Action
A	The proposed action is not likely to produce stressors that have direct or indirect adverse consequences on the environment.	True	End
	Available Evidence: The PA will produce multiple stressors that will adversely affect the Migratory Corridors and Habitat for Rearing including, but not limited to: impingement and entrainment, and effects related to altered flows and temperatures.	False	Go to B
	Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of	True	NLAA
В	the direct or indirect consequences of the proposed action.  Available Evidence: Areas of designated critical habitat for sDPS green sturgeon will be exposed to multiple stressors produced by the PA, including to habitats such as: Freshwater Rearing Habitat for Juveniles; Freshwater Migratory Corridors for Outmigrating Juveniles and Spawning Adults; and Estuarine Habitat for Rearing and Migration.	False	Go to C
С		True	NLAA

Step	Apply the Available Evidence to Determine if	True/False	Action
	The quantity or quality of any physical or biological features or primary constituent elements of critical habitat or capacity of that habitat to develop those features over time are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action.  Available Evidence: In multiple instances the quantity and quality of the PBFs of green sturgeon designated critical habitat, will be reduced by the PA. For example, suitability of water temperature and flow in lower reaches of spawning habitat are expected to be reduced by operation of the PA.	False	Go to D
	Any reductions in the quantity or quality of one or more physical or biological features or primary constituent	True False	NLAA
D	elements of critical habitat or capacity of that habitat to develop those features over time are not likely to reduce the value of critical habitat for the conservation of the species in the exposed area.  Available Evidence: The reductions in quantity and quality of PBFs, as well as the reductions in the capacity of the critical habitat to develop these features over time is expected to reduce the value of the habitat; particularly with regard to juvenile and adult migratory corridors in the Delta.		Go to E
	Any reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are not likely to appreciably diminish the overall value of critical habitat for the conservation of the species.	True	No D/AD MOD
Е	Available Evidence: Although individual PBFs in several exposed areas will be diminished, the exposed areas represent a small portion of habitat within the broader context of the available designated critical habitat with intact PBFs.  Therefore, considering the relative size and scale of the exposed areas within the context of the broader designated critical habitat as a whole, the overall value of the critical habitat for the conservation of the species is not expected to be appreciably diminished.	False	D/AD MOD

### 2.8.9 Southern Resident Killer Whale

• Listed as endangered (70 FR 69903; November 18, 2005)

Detailed information regarding the life history and status of federally listed SRKW distinct population segment (DPS) of killer whales can be found in Section 2.2.5 Rangewide Status of the Species and Critical Habitat.

### 2.8.9.1 Status of the Species and Environmental Baseline

In summary, the SRKW DPS is at a high risk of extinction primarily from low abundance and impaired survival and fecundity, especially in recent years. Major threats to this species include limitations in available preferred prey (Chinook salmon), vessel and sound impacts, contaminants, and climate change. SRKWs would benefit from the recovery of Chinook salmon populations and increased access to prey, as well as protections to reduce the impacts of vessels and sound, as well as reduced exposure to contaminants in prey items and in the marine environment.

At present, the SRKW population has declined to the lowest levels seen in over thirty years. Recent updates to population viability analyses suggest a continued downward trend in population growth projected over the next 50 years (National Marine Fisheries Service 2016e). This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (National Marine Fisheries Service 2016e). Recent analyses have concluded the effects of prey abundance on fecundity and survival have a large impact on the potential population growth rate (Lacy et al. 2017). When prey is scarce, SRKWs likely spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition, can lead to reduced body size of individuals and to lower reproductive and survival rates of a population (Trites and Donnelly 2003). Recent aerial surveys of the SRKW population have detected declines in the body condition before the death of seven individuals and provided evidence of a general decline in SRKWs body condition in recent years (Trites and Rosen 2018).

The diet data indicate that Chinook salmon is the primary prey for SRKWs year round, presumably because of Chinook salmon's large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Sighting reports, satellite-linked tag deployments, and other data indicate that K and L pods use the coastal waters along Washington, Oregon, and California during the winter and spring; occasionally as far south as Monterey Bay. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicate that Chinook salmon from the Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon comprise over 90 percent of the whales' coastal Chinook salmon diet during that time period (NWFSC unpublished data). In general, over the past decade, some Chinook salmon stocks within the range of SRKWs have had relatively high abundance (e.g. Washington and Oregon coastal stocks, some Columbia River stocks) compared to the previous decade, whereas other stocks originating in the more northern and southern ends of the whales' range (e.g. most Fraser stocks, Northern and Central British Columbia stocks, Georgia Strait, Puget Sound, and Central Valley) have declined. Changing ocean conditions driven by climate change may influence ocean survival of Chinook and other Pacific salmon, further affecting the prey available to SRKWs.

On average since the early 1980s, it appears that CV Chinook salmon (as represented by the SI) constitutes about 20 percent of the total catch and escapement of all Chinook salmon populations

that are likely encountered by SRKWs from British Columbia to California, although this proportion varies from about 10-30 percent each year depending on varying strengths in run size (Kope and Parken 2011). As a result, we conclude that CV Chinook salmon make up a sizeable and significant portion of the total abundance of Chinook salmon available to SRKWs throughout their range in most if not all years; likely at least several hundred thousand individual fish other than during years of exceptionally low abundance for CV Chinook salmon. In addition, the known distributions of Chinook salmon along the coast suggest that CV Chinook salmon are an increasingly significant prey source (as SRKWs move south along the U.S. West Coast) during any southerly movements of SRKWs along the coast of Oregon and California that may occur during the winter and spring, constituting the majority of fish along some areas of the U.S. West Coast at times (Weitkamp 2010, Bellinger et al. 2015, Shelton et al. 2019).

In addition, DDT fingerprints suggest fish from California form a significant component of their diets (Krahn et al. 2007, Krahn et al. 2009, O'Neill et al. 2012). In total, the available data suggest that CV Chinook salmon constitute a sizeable percentage of Chinook salmon that would be expected to be encountered by SRKWs in coastal waters off California and Oregon, and at least a small portion of Chinook salmon in the ocean as far north as British Columbia. As a result, we conclude that CV Chinook salmon are an important part of the diet for most SRKWs during portions of the year when SRKWs occur in coastal waters off the North American coast, especially south of the Columbia River, which includes the times of potential reduced body condition and increased diet diversity that received additional weight during the recent prey prioritization process.

There are numerous additional factors that are affecting Chinook salmon and the availability of prey in the action area. Chasco et al. (2017) concluded that these increases in marine mammal predation of Chinook salmon could be masking recovery efforts for salmon stocks, and that competition with other marine mammals may also be limiting the growth of the SRKW population. The harvest of Chinook salmon that may overlap with SRKWs occurs at a large international scale; generally, on the order of approximately 20 percent of Chinook salmon that may be available as prey for SRKWs. As part of the recent the Pacific Salmon Treaty negotiation, the U.S. agreed to develop a targeted funding initiative to mitigate the effects of harvest and other limiting factors by investing in habitat and hatchery actions to increase prey available for SRKWs (National Marine Fisheries Service 2019b). However, Chinook salmon from these hatcheries may only overlap with the small proportion of Chinook salmon from the Central Valley that range up to the Columbia River area and northward. Recently, NMFS completed consultation on the operation of the Klamath River water project from 2019-2024, which included measures to address disease concerns for juvenile Chinook salmon and coho salmon in the Klamath Basin (National Marine Fisheries Service 2019a). The analysis concluded that hundreds or thousands of more adult Chinook salmon from the Klamath River will be available for SRKWs off the coast of California and Oregon during some years over the next decade, especially for brood years that may have been exposed to more stressful conditions.

# 2.8.9.2 Summary of Proposed Action Effects

Overall, the productivity of CV Chinook salmon, especially the dominant fall-run population, appears to be decreasing over time. This is likely a result of many important factors, including the ongoing effects of water operations on the survival of productivity of all CV Chinook salmon populations. Individual stressors resulting from the PA such as increased water temperatures,

reduced survival from routing through the Delta, redd dewatering, and entrainment/salvage in water operations negatively affect the fitness and survival of individuals from all CV Chinook salmon populations runs. In particular, these factors may be especially significant for non-ESA listed Chinook salmon populations such as fall-run Chinook salmon, because there are fewer measures under the PA to minimize the impacts of operations on the non-ESA listed populations. In the past, there has been some analysis (National Marine Fisheries Service 2009b) showing decreased productivity for natural populations of fall- and late fall-run Chinook salmon as a result of water operations on the order of 10 percent. While it is uncertain how that compares to operations under the PA, it seems likely that the PA continues to reduce productivity of the CV Chinook salmon at least at similar levels as before. For ESA-listed Chinook salmon ESUs in the Central Valley, we conclude that population level effects for ESA-listed species and critical habitats overall under the PA are significant across multiple VSP parameters, including abundance. Generally, we expect that non-ESA-listed populations are similarly impacted by the same stressors across the spectrum of VSP parameters.

With respect to the PA compared to COS, a relatively small decrease in overall productivity for Chinook salmon in total under PA was estimated (<1 percent), largely as a result of the decrease in productivity expected for the dominant fall-run Chinook salmon populations. However, we recognize that these estimates could not account for all stressors on all Chinook salmon populations affected by the PA. We expect a reduction in productivity under the PA to lead to an additional reduction in the number of adults in ocean (on average) compared to COS, on top of the ongoing perpetual reduction and limitation of productivity that is expected to occur under COS.

The June 14, 2019 final PA included a number of additional elements and conservation measures that may help to minimize impacts to CV Chinook salmon populations. As described 2.5.8.2 Supplemental Analysis of June 14, 2019, none of these measures are quantitatively assessed within any framework similar to the results presented in Section 2.5.8.1.4 Changes in Chinook Salmon Productivity under the PA compared to COS at this time. Some of the revised PA elements, such as Revisions to the Cold Water Pool Management and development of Upper Sacramento Performance Metrics (Section 4.10.1.3.3), or Revisions to the Governance Sections of the PA to include additional Drought and Dry Year Actions (Section 4.12.5) and Chartering of Independent Panels (Section 4.12.6) and Four-Year Reviews (Section 4.12.8) ultimately do not affect the modeling results used to characterize the exposure of the species to stressors such as increased water temperature, or the risk based on the expected long-term proportion of years in each Tier type. There are expectations for revised PA elements such as OMR management and performance objectives intend to limit impacts (i.e., salvage loss) under the PA to levels comparable to what would occur under the COS. However, as described in 2.5.8.2 Supplemental Analysis of June 14, 2019 there are some uncertainties in how new approaches will be implemented and uncertainties associated with effects. For other elements, such as the SRSC Partnership establishment and implementation of the Mainstern Sacramento River Integrated Water and Fish Science and Monitoring Partnership, studies into alternate release strategies for hatchery fall-run Chinooks salmon from CNFH, and construction of a fish trapping and sorting facility at CNFH, it is not possible to describe their benefits more specifically at this time based due to limited information on their effectiveness and/or uncertainty on how these actions will ultimately be incorporated into future project operations.

Finally, Reclamation identified a number of these restoration actions or programs that have been occurring, and which are expected to continue into future, in addition to proposing restoration actions linked to the PA. These ongoing and new restoration actions are expected to improve Chinook salmon habitat.

Based on the analysis, it is likely that conditions under the PA where SRKWs are exposed to and affected by reductions and limitations in the abundance of Chinook available as prey as a result of the PA will continue and increase over time. The analysis determined that this exposure would lead to changes in the foraging behavior of SRKW in the action area and increased risks of nutritional stress for individual SRKWs, and that all members of K and L pod are expected to be harmed through the increased risk of impaired foraging due to decreased Chinook salmon abundance in the ocean resulting from these effects. While revised PA measures and proposed restoration actions offer some benefit for Chinook salmon productivity compared to the original PA, there is not enough information to clearly indicate that Chinook salmon productivity in the Central Valley will not continue to diminish over time under the PA. The effect of perpetual and/or additional nutritional stress over time for individual SRKWs that are already experiencing and showing signs of nutritional stress is an additional reduction in fitness that increases the risk of reduced survival and/or reproductive success for at least some members of the SRKW population that are already compromised, or potentially contributing to diminishing the fitness of individuals to a compromised state over time where reduced survival and/or reproductive effects become increasingly likely to occur.

# 2.8.9.3 Assess Risk to the Population/DPS

The available information presented in Section 2.2.5 Rangewide Status of the Species indicates that a number of SRKW individuals have been showing signs of nutritional stress, poor health; and some of these individuals have subsequently died. In addition, and at least partly as a result of these recent developments, the most recent assessments of the SRKW population indicate that fecundity of the population has been low and that the population is expected to continue to decline in the future if the population dynamics of the population (survival and fecundity) do not improve.

The available information indicates that CV Chinook salmon (especially the fall-run populations) is a significant source (10-30 percent) of Chinook salmon abundance during the winter and spring time in coastal waters where SRKWs occur during the time period when we believe prey resources are most limiting for SRKWs. The available information also indicates that CV Chinook salmon are increasingly prominent and dominant components of available Chinook salmon prey resources as SRKWs head south along their range. Given the significance of CV Chinook salmon to the abundance of Chinook, we conclude that reductions and limitations in the productivity of CV Chinook salmon would affect the foraging behavior of SRKWs.

Under the PA, our analysis concludes that SRKWs will continue to be exposed to decreased abundances of CV Chinook salmon as a result of reduced productivity as a result of the PA and limited by the overall low rates of juvenile Chinook salmon survival in the Central Valley. As proposed, the PA does not improve prospects for available Chinook salmon prey resources for SRKWs; but instead the PA would further contribute to additional nutritional stress of at least some SRKW individuals. Over the long term, the reduction in Chinook salmon productivity in the Central Valley will likely not relent under the PA, but instead will likely continue to escalate if the productive capacity of the Central Valley system, especially for fall-run Chinook salmon,

continues to diminish and as some ESA-listed Chinook salmon populations are increasingly unlikely to recover and head closer to extinction.

We conclude that the PA is expected to diminish VSP parameters and increase extinction risk of ESA-listed units of salmon. In the NMFS 2009 Opinion, we concluded the continued decline and potential extinction of winter-run and CV spring-run populations, and consequent interruption in the geographic continuity of salmon-bearing watersheds in the SRKWs' coastal range, was likely to alter the distribution of migrating salmon and increase the likelihood of localized depletions in prey, with adverse effects on the SRKWs' ability to meet their energy needs. The PA removes some of the RPA measures that were required in 2009; and does not contain many protective measures designed to address significant stressors for the non-listed populations that are responsible for a large portion of Chinook salmon production in the Central Valley.

The trend in Chinook salmon productivity in the Central Valley is of concern to the long-term outlook for available prey resources for SRKWs. Currently, overall productivity of this system depends heavily on modified hatchery release practices to minimize impacts from the PA and other factors in the Central Valley. As a result, the PA will continue to exacerbate the proportional larger impact of water operations on the natural production of Chinook salmon from the system, which illustrates the fundamental limitations on productivity that exist in this system, in part as a result of the PA.

The increased risks of reduced survival and/or reproductive success for at least some members of the SRKW population, the diminished productivity of all Chinook salmon populations including fall-run Chinook, and the increased risks of extinction for ESA-listed Chinook salmon, that are expected to occur as a result of the PA have significant implication for the viability of the SRKW population. Given the current forecast of population declines for this small population, risks of additional mortality and/or reduced fecundity would likely expedite population declines and present significant obstacles to the recovery and ultimate survival of this population. The available information suggests that large changes in individual survival and reproduction rates are necessary in order for SRKW to recover (and even survive). The prospect for persistent and escalating risks of reduced survival and reproductive success associated with reduced prey resources and diminishing Chinook productivity from the Central Valley heading into the future increasingly limit the possibility that SRKWs can recover given the compromised status of the population and signals of poor health for numerous individuals that are already being observed. Considering the effects of the PA, cumulative effects, and effects from interrelated and independent actions in the context of the status and environmental baseline of SRKWs, NMFS concludes that the PA is likely to appreciably reduce the likelihood of both the survival and recovery of SRKWs.

# 2.9 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the ROC on LTO, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the ROC on LTO is:

 likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and likely to destroy or adversely modify any of their designated critical habitats;

- likely to jeopardize the continued existence of Southern Resident killer whales; and
- not likely to jeopardize the continued existence of the southern DPS of North American green sturgeon, and not likely to destroy or adversely modify its designated critical habitat.

### 2.10 Reasonable and Prudent Alternatives

"Reasonable and prudent alternatives" (RPA) refer to alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that are economically and technologically feasible, and that would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat (50 CFR 402.02).

Regulations also require that NMFS review all relevant information provided by the Federal agency or otherwise available, evaluate the current status of the listed species or critical habitat, evaluate the effects of the action and cumulative effects on the listed species or critical habitat, and discuss the basis for any findings and any RPAs with the action agency and utilize the action agency's expertise in formulating the RPA (50 CFR 402.14(g)(5)). This RPA was developed through a thoughtful and reasoned analysis of the key causes of the jeopardy and adverse modification findings, and a consideration of alternative actions within the legal authority of Reclamation and DWR to alleviate those stressors. The actions in this RPA have been discussed in the context of NMFS recommendations to Reclamation over the course of multiple Tiger Team meetings in November through December, during the development of the draft biological assessment; and during meetings that were held throughout the consultation period, between February 5 and June 14, during which NMFS provided verbal and written recommendations to Reclamation to address significant adverse effects of the PA. These recommendations were not included by Reclamation in changes to the February 5, April 30 or June 14 revisions to the proposed action.

NMFS concentrated on actions that have the highest likelihood of alleviating the stressors with the most significant effects on the species, rather than attempting to address every project stressor for each species or every PBF for critical habitat. For example, water temperatures lethal to incubating eggs often occur downstream of Shasta and Keswick reservoirs when the air is warm and flows are low. Fish cannot reach spawning habitat with colder water at higher elevations if it is above currently impassable dams. Accordingly, NMFS' near-term measures provide suitable water temperatures below dams in a higher percentage of years, and long-term measures provide passage to cooler habitat above dams as soon as practicable. Reducing egg mortality from high water temperatures is a critical step in slowing or halting the decline of Central Valley salmonids.

There are several ways in which water operations adversely affect listed species that are addressed in this RPA. We summarize the most significant here:

Water operations result in elevated water temperatures that have lethal and sub-lethal
effects on egg incubation and juvenile rearing in the upper Sacramento River. The
immediate operational cause is lack of sufficient cold water in Shasta Reservoir to reduce

- downstream temperatures at critical times and meet other project demands. This elevated temperature effect is particularly pronounced in the Upper Sacramento River for winterrun Chinook salmon. The RPA includes a new year-round storage and temperature management program for Shasta Reservoir and the Upper Sacramento River, as well as long-term passage prescriptions at Shasta Dam and re-introduction of winter-run Chinook salmon into its native habitat in the McCloud and/or Upper Sacramento rivers to minimize these effects to ecologically acceptable levels for winter-run Chinook salmon.
- 2) PA operations in Clear Creek are expected to result in suboptimal flows and water temperatures for portions of the CV spring-run Chinook salmon holding, spawning, egg incubation periods in some years. The RPA calls for improved approaches to achieve essential flows and water temperatures during these life stages.
- 3) Both Reclamation and DWR's winter and spring operations associated with retention of natural flows result in adverse effects through reduced frequency and magnitude of rearing habitat inundation. To minimize these effects, the PA includes "scheduling" action components (spring pulse flows) and "collaborative planning" action components (habitat restoration). The 2016 FERC opinion includes related actions in the Feather River. This RPA contains additional both short-term and long-term actions necessary to minimize effects to juvenile rearing habitat in the Lower Sacramento River and northern Delta.
- 4) The effects analysis shows that juvenile CCV steelhead migrating out from the San Joaquin River Basin are exposed to significant high magnitude stressors and have low survival rates due to the proposed action. The RPA mandates additional measures to improve survival of San Joaquin CCV steelhead smolts, including both increased San Joaquin River flows and export curtailments. Given the uncertainty of the relationship between flow and exports, the RPA also prescribes a significant new study of acoustic tagged fish in the San Joaquin Basin to evaluate the effectiveness of the RPA and refine it over the lifetime of the project.
- 5) The Nimbus Fish Hatchery steelhead program contributes to both loss of genetic diversity and mixing of natural and hatchery stocks of steelhead, which reduces the viability of natural stocks. The Nimbus Fish Hatchery program for non-listed fall-run Chinook salmon also contributes to a loss of genetic diversity, and therefore, viability, for fall-run Chinook salmon. To minimize these effects, the PA includes development of Hatchery and Genetic Management Plans (HGMP) to improve genetic diversity of both steelhead and fall-run Chinook salmon, the latter of which is an essential prey base of SRKW. The RPA sets some specific requirements for HGMP development and requires additional development and implementation of plans for alternative hatchery release strategies/increased hatchery production with the goal of increasing survival of all fall-run Chinook salmon as part of the HGMP for fall-run Chinook salmon at Nimbus Fish Hatchery.
- 6) The effects analysis shows that Chinook salmon productivity in the Central Valley, including especially non-listed fall-run Chinook salmon populations, is increasingly diminished by the PA, which increases the risks associated with reduced Chinook prey availability for SRKW. The RPA requires measures designed to minimize significant stressors for Chinook salmon in both upstream areas and through the Delta, actions to improve Chinook salmon productivity in the Central Valley to reduce these risks for

SRKW, along with initiatives to support development of information and tools that can be used to inform and improve these measures over time.

An RPA must avoid jeopardy to listed species in the short term, as well as the long term. Essential short-term actions are presented for each division and are summarized for each species to ensure that the likelihood of survival and recovery is not appreciably reduced in the short term (i.e., one to five years). In addition, because the proposed action is operation of the CVP/SWP until 2030, this consultation also includes long-term actions that are necessary to address project-related adverse effects on the likelihood of survival and recovery of the species over the next decade.

NMFS considered the consistency with the scope of the intended purpose of the proposed action, Reclamation and DWR's legal authority and jurisdiction, and made considerations regarding the economic and technological feasibility in several ways when developing actions in this RPA. The RPA also allows for tailored implementation of many actions in consideration of economic and technological feasibility without compromising the RPA's effectiveness in avoiding jeopardy and adverse modification of critical habitat.

The RPA includes opportunities for independent scientific review of all actions to further the scientific understanding of the stressors and actions and to create a process for adaptively managing actions based on the findings and recommendations of these review.

# 2.10.1 Organization of the RPA

The specific actions in the RPA are detailed below. That section begins with overarching actions that apply to operations in all geographic divisions of the project, including procedures for orderly functioning of the many technical teams that assist with decision making, research and adaptive management, and monitoring. These are followed by suites of actions specific to most geographic divisions of the proposed action: Shasta, American River, East Side (Stanislaus River), and the Delta. Notwithstanding specific attribution to Reclamation below, RPA actions are to be implemented jointly by Reclamation and DWR.

The RPA also includes a species-by-species explanation of how each action contributes to avoiding jeopardy or adverse modification for that species, and the basis for NMFS' conclusion that the RPA actions are likely to avoid jeopardizing the species or adversely modifying or destroying its critical habitat.

# 2.10.1.1 RPA Actions By Division

# **Trinity River Division (Clear Creek)**

# Action CC.1: Improvements to Flow and Water Temperature Management in Clear Creek

**Objective:** Decrease risk to Clear Creek CV spring-run Chinook salmon and CCV, steelhead populations through improved flow and water temperature management.

# Action CC.1.a: Reservoir Water Temperature Model

Reclamation shall develop a water temperature model for Whiskeytown Reservoir, expanding the Watercourse Engineering model for Keswick and Shasta Reservoirs, to capture the inter-

connections of the Trinity-Sacramento River systems for efficient use of cold-water resources. A model would enable better forecasting and planning for Clear Creek to provide protective water temperatures for CV spring-run Chinook salmon during holding, spawning, and egg incubation. Water temperature impacts from hydropower peaking shall be considered during model development. Final model, including recommendation for implementation, due August 1, 2022, to NMFS.

# Action CC.1.b: Whiskeytown Dam Structural Improvement Evaluation

Reclamation shall evaluate feasibility and fish benefits of structural improvements to Whiskeytown Dam to improve cold-water pool availability. Improvements to be evaluated include, but are not limited to: the locations of outlets and options for configurations; siphon; and temperature control device that allows for selective withdrawal. Draft report due August 1, 2023, to NMFS. Final report, including recommendation for implementation, due August 1, 2024, to NMFS.

# Action CC.1.c: Long-term Flow and Water Temperature Prescription

Reclamation shall develop a long-term flow and water temperature prescription (plan) to achieve various ecological functions in Clear Creek. The plan shall include incorporation of the reservoir water temperature model, and consideration of monitoring data on CV spring-run Chinook salmon and CCV steelhead and best available scientific publications on ecological channel function, fluvial processes, sediment transport, flow regimes, and fish habitat needs. Reclamation shall develop a plan that to the extent possible shall include the following prescriptions:

- i. encourage upstream movement of CV spring-run Chinook salmon to preferred habitat in July and August, including water temperature or flow adjustments
- ii. operate between 53°F and 56°F at IGO, September 15 through October 31
- iii. shift the water temperature compliance point from IGO at river mile 11.0 downstream to Clear Creek Road Bridge at river mile 8.59
- iv. protect earlier egg incubation if present (prior to September 15), and any redds downstream of IGO, by implementing a gradual flow increase and water temperature cooling

Reclamation shall operate flow releases and water temperatures as described in the proposed action until the long-term flow and water temperature plan is developed. Alternative operations developed in the plan are subject to NMFS review and concurrence.

**Rationale:** Operations in Clear Creek are expected to result in suboptimal flows and water temperatures for listed salmonids in Clear Creek. These measures would support optimization of flows and water temperatures on Clear Creek.

# **Shasta Division**

# Action SD.1: Shasta Cold Water Pool Management – Develop Temperature Dependent Egg Mortality and Egg to Fry Survival Objectives

The PA, as updated on June 14, 2019, contains new performance measures that NMFS fully supports. These will be helpful in tracking whether the PA performs as modeled. However, due to the ongoing effects of temperature related mortality and its contribution to NMFS' finding of jeopardy and adverse modification of critical habitat for winter-run Chinook salmon, NMFS

concludes the following supplemental tier frequency and associated temperature dependent egg mortality and total survival objectives are necessary to maintain population viability.

Objective: Reduce temperature dependent egg mortality and egg to fry mortality by creating management objectives that support population-scale viability for winter-run Chinook salmon below Shasta and Keswick dams.

# SD.1.a - Tier Frequency Objectives

- a. Reclamation shall operate to Tier 1 conditions in at least 2 out of 3 years, and shall operate to Tier 2 or Tier 3 conditions in no more than 1 out of 4 years. Reclamation shall operate to Tier 4 conditions in no more than 1 out of 10 years.
- b. Reclamation shall make operational adjustments as necessary to meet these objectives, including, but not limited to: retaining storage in April, May, June and July, if effective in meeting objectives, by limiting Keswick Dam releases and resulting downstream deliveries; re-operating to meet downstream needs through releases at Folsom and Oroville reservoirs, provided operational minimum requirements are met and notwithstanding incurring COA debt; foregoing hydropower; and further limiting fall releases.
- c. If Reclamation operates to a Tier 2 or 3 year with greater frequency than what is expected (described above) for more than two consecutive years, or a Tier 4 year for more than 1 out of 10 years, an independent review panel shall be established by the end of the calendar year to determine the degree to which operational decisions affected the frequency. The panel shall review whether the above water operation in subsection "b" actions were taken to maintain a Tier, and if so, analyze whether Reclamation made all possible operational adjustments to attempt to meet the objectives in subsection "a"; or conversely, whether hydrology/meteorology provided conditions that under which meeting the objectives was beyond Reclamation's control. The panel will make recommendations on actions that may be taken to reduce the likelihood for tier frequency exceedance. Reclamation shall submit a report to NMFS within two months of the panel report on what changes, if any, Reclamation plans to make as a result of the review.

# SD.1.b - Survival Objectives in Tier 1 Years

- a. Reclamation shall not exceed an annual temperature dependent mortality (TDM) of 2 percent (based on the Martin et al. 2017, model of TDM) OR
- b. Reclamation shall operate such that total egg-to-fry survival (ETF) is at least 32 percent (as calculated by CDFW winter-run Chinook salmon escapement estimates and USFWS' estimated juvenile winter-run Chinook salmon passage counts at RBDD).
- c. If neither of these metrics are met, this year may be considered a Tier 2 or Tier 3 year for the purposes of accounting for the probability of operating in a Tier as long as the survival objectives in Tier 2/3 are met. If the survival objectives of a Tier 2/3 year are not met, then this shall be considered a Tier 4 year for purposes of accounting for expected frequency. However, if considering the current year as a higher tier year would exceed the expected frequency of operating in that tier, reinitiation of consultation would be required.

# SD.1.c - Survival Objectives in Tier 2 and Tier 3 Years

- Reclamation shall not exceed an annual TDM of 12 percent TDM (based on the Martin et al. 2017 model of TDM) OR
- b. Reclamation shall operate such that total ETF survival is at least 27 percent (as calculated by CDFW winter-run Chinook salmon escapement estimates and USFWS' juvenile winter-run Chinook salmon passage counts at RBDD).
- c. The first 5 years of implementing the opinion will be operated such that there are no more than three consecutive years of Tiers 2, 3, or 4 in any combination.
- d. If neither of these metrics in subsections "a" and "b" are met, this year may be considered a Tier 4 year for the purposes of accounting for the probability of operating in a Tier. However if considering the current year as a Tier 4 year would exceed the expected frequency of operating in that tier, reinitiation of consultation would be required.

# SD.1.d - Survival Objectives in Tier 4 Years

- a. Reclamation shall target ETF survival of 15 percent or greater; AND
- b. Reclamation shall target end-of-September carry-over storage of at least 1.9 MAF; AND
- c. Reclamation shall implement intervention measures in consultation with NMFS.

# SD.1.e - Collaborative Strategy Provisions

- a. Reclamation may, at any time during the implementation of the Opinion, convene, with NMFS, an independent panel to review the Tier Frequency, temperature dependent egg mortality and total survival objectives described in SD.1.a – SD.1.d to review and develop alternative objectives that they shall operate to, subject to NMFS review and concurrence.
- b. If Reclamation decides to initiate such a review, Reclamation shall charter an independent panel consistent with "Chartering of Independent Panels" under the "Governance" section of the June 14, 2019, final PA.
- c. Reclamation may at any time request that NMFS provide relief from meeting these objectives, and/or reassess the biological necessity of meeting these objectives below Shasta Dam, due to successful acceleration of reintroduction efforts in Battle Creek and McCloud rivers, per actions below.

Rationale: Winter-run Chinook salmon require conditions that prevent frequent high mortality events and support viability of the species despite demands of operations. The species is likely to absorb the stress associated with an infrequent (i.e., 1 in 10 year) high-mortality year. However, to support viability, survival rates should not be low for several consecutive years, and should be at levels similar to or improved upon recent rates. NMFS considers the multiple mortality sources and potential opportunities to increase survival through non-flow actions by identifying temperature-dependent mortality metrics and overall egg-to-fry survival metrics. Note that exceedance of an objective is not equivalent to exceeding take or being considered out of compliance. See the ITS for more details on the amount or extent of take exempted.

### Action SD.2 – Shasta Fish Passage Pilot Program

Beginning in January 2020, Reclamation shall undertake a 10-year phased winter-run Chinook salmon pilot passage program to evaluate the long-term feasibility of reintroducing winter-run Chinook salmon into their historical holding, spawning, and rearing habitats above Shasta Dam.

**Objective:** Reduce extinction risk of Sacramento River winter-run Chinook salmon and mitigate for CVP water project operation effects.

# SD.2.a - Interagency Fish Passage Steering Committee

Reclamation shall re-convene the Interagency Fish Passage Steering Committee (Committee) by January 2020. The Committee shall be re-established in consultation with and the approval of NMFS. The Committee shall include experienced biologist and engineers with expertise in fish passage design and operation, reintroduction techniques, permitting, and salmonid biology. All membership to the committee must be approved by Reclamation and NMFS. Committee membership shall include one lead member and one alternate. If a formal charter for the Committee, pursuant to FACA, is delayed for more than three months following the re-start of the Committee, Reclamation shall provide updates to all interested members of the public on Committee decisions a minimum of three times a year.

# SD.2.b - Adult Winter-run Chinook Salmon Release Site(s) Above Shasta Dam and Winter-run Chinook Salmon Juvenile Release Site(s) Below Keswick Dam

Reclamation shall transport adults to habitats above Shasta Dam and juveniles (from spawning above Shasta Dam) to habitats below Keswick Dam using safe, timely and effective release methods and protocols. Transport and release locations and methods shall follow existing State and Federal protocols. With assistance from the Committee, and in coordination with applicable landowners and stakeholders, Reclamation shall complete construction of all selected adult and juvenile release sites by October 31, 2021.

# SD.2.c - Juvenile Fish Collection Prototypes

Since 2010, Reclamation has made considerable progress on concepts for juvenile fish collection facilities above Shasta Dam. Reclamation shall continue the development of juvenile fish collection facilities above Shasta Dam. Pilot efforts already explored include installation of two prototype juvenile salmonid collection facilities in the lower riverine portion of the McCloud River and the upper McCloud arm of Shasta Reservoir. By September 1, 2020, Reclamation shall fund, design, construct, install, and operate both collection systems.

# SD.2.d - Broodstock SR Winter-run Chinook Salmon from the Livingston Stone National Fish Hatchery

From January 1, 2020 through December 31, 2023, Reclamation shall use juvenile and adult winter-run Chinook salmon broodstock from the Livingston Stone NFH during the initial stages of the reintroduction program. Reclamation shall provide funding for broodstock production and, if necessary, expansion of the Livingston Stone NFH broodstock program within one year of a determination by the Committee. Expansion may be required if adequate numbers of fish are not available to assess the effectiveness of the reintroduction program or adequately seed upstream habitat during years of low natural adult returns.

# SD.2.e - Transition to Natural Winter-run Chinook Salmon

By December 31, 2023, if the Committee determines the preliminary stages of the pilot project are successful (*e.g.*, adult holding, spawning, and juvenile survival and collection), Reclamation shall transition to using natural winter-run Chinook salmon obtained from the Keswick Dam fish collection facility. The Steering Committee, in collaboration with the NMFS SWFSC, shall develop strategies that minimize risk to the existing natural population below Keswick Dam. Numbers of natural adult SR winter-run Chinook salmon to be used for reintroduction shall be set by the Steering Committee in consultation with the NMFS Southwest Fisheries Science Center.

# SD.2.f - Project Effectiveness, Monitoring and Evaluation for Winter-run Chinook Salmon

From January 1, 2020, through December 31, 2030, Reclamation shall fund and implement all phases of the pilot program for winter-run Chinook salmon. The objective is to gather sufficient biological and technical information to assess the relative effectiveness of the program, including the following; (a) the biological response of winter-run Chinook salmon to historical habitats above Shasta Dam, (b) juvenile collection efficiency, and (c) preliminary estimates of cohort replacement rates. A report shall be provided to the Committee for review and comment by March 31 of year 5 and a final report of the pilot effort shall be completed by year 10. Prior to issuing the final report, Reclamation submit the draft final report for independent scientific peer review. All of the reports shall summarize the findings from SD.2a through SD.2.c, above. The final report shall include recommendations regarding long-term fish passage actions.

# SD.2.g - Dynamic Distribution Model and Plan

By year 4, Reclamation, in cooperation with NMFS, shall draft a Dynamic Distribution Model and Plan detailing how LSNFH practices (including annual supplementation, captive broodstock and drought year production supplementation), and fish reintroduction actions (Battle Creek and McCloud River) can be used, in synchrony with Reclamation's Tier 3 and Tier 4 water temperature management plans and the intervention measures proposed for Tier 4, to reduce the exposure and risk of winter-run Chinook salmon downstream from Shasta and Keswick dams, and allow for long-term recovery. The model and plan shall be submitted for independent review, and shall inform related annual actions in the PA and this RPA following peer review. Reclamation shall complete a final model and plan by year 8.

Rationale: The analysis in the opinion finds that even after all discretionary actions are taken to implement the 4-tiered approach to Shasta Cold Water Pool Management Program the risk of temperature-dependent egg mortality persists, especially in critically dry years. This mortality can be significant at the population level. The analysis also leads us to conclude that due to climate change, the frequency of critically dry years will increase. Additionally, the longer an action impedes recovery of an ESU with a single spawning population, the more it increases the risk of extinction due to continued exposure to stochastic events and a declining background environmental conditions. Existing habitat that was historically occupied by winter-run Chinook salmon in the McCloud River remains in excellent condition for holding, spawning, egg incubation and rearing.

The concept for reintroduction above Shasta is not new and was first proposed in the NMFS 2009 opinion and identified in the NMFS 2014 recovery plan as a high priority recovery action. Additionally, from 2010 through July, 2018, Reclamation has led, and provided necessary funding for, the Shasta Dam Fish Passage Evaluation project. This RPA action will continue that effort to and will improve the scientific and management understanding of how reintroducing

winter-run Chinook salmon to historic habitat in the McCloud River can be used to reduce risk to winter-run Chinook salmon, particularly during Tier 3 and 4 years when temperature-dependent egg mortality below Keswick Dam can be very high. Specifically, Reclamation accomplished the following steps:

- Formation of an Interagency Fish Passage Steering Committee along with various subcommittees;
- Completion of an evaluation of habitat in the upper Sacramento and McCloud rivers;
- Completion of a pilot implementation plan;
- Funded DWR for critical engineering work which resulted in a contract being awarded for construction, installation and preliminary testing of juvenile collection facilities;
- Requested NMFS designate winter-run and CV spring-run Chinook salmon as nonessential experimental populations when above Shasta Dam;
- Funded an expansion of the Livingston Stone NFH to provide winter-run Chinook salmon broodstock for the initial reintroduction efforts;
- Conducted extensive public outreach and workshops;
- Funded U.S. Geological Survey to assess juvenile reservoir transit and other critical future aspects of the pilot program; and
- Completed a draft National Environmental Policy Act document ready for public comment.

# Action SD.3 – Battle Creek Restoration and Winter-run Reintroduction Acceleration Program

**Objective:** Implement key actions necessary to accelerate the Battle Creek Restoration Program and implement the Battle Creek winter-run Chinook salmon Reintroduction Plan.

# SD.3.a – Reclamation Shall Complete a Battle Creek Acceleration Plan by December 31, 2020 and Provide all Necessary Funding to Ensure Timely Implementation.

- a. The purpose of the plan is to ensure continued funding additional actions that are necessary to assist with the completion of the Battle Creek Salmon and Steelhead Restoration Program and to support the certainty of establishing an additional population of winter-run Chinook salmon.
- b. The plan shall be developed with technical assistance from the NMFS, USFWS and CDFW and shall:
  - i. Identify and implement, to the maximum extent practicable, a suite of no-regrets actions that can be planned and carried out while the disposition of the PG&E hydroelectric project is in process. For the purpose of this RPA, "no regrets" actions are defined as those actions that can move forward on Battle Creek that are not directly tied to future decisions related to the disposition PG&E's hydroelectric license on Battle Creek;
  - Describe a strategy for integrating the Battle Creek winter-run Chinook salmon jump-start project with the long-term Battle Creek Winter-run Chinook Salmon Reintroduction Plan;

- iii. Develop the infrastructure necessary to complete the Battle Creek Reintroduction Plan for Winter-run Chinook Salmon (as described in Table 15 of the 2016 Battle Creek Winter-run Chinook Salmon Reintroduction Plan);
- Fund the ongoing operational costs of the Battle Creek Reintroduction Plan for Winter-run Chinook Salmon (as described in Table 15 of the 2016 Battle Creek Winter-run Chinook Salmon Reintroduction Plan); and
- v. Identify and support science actions such as marking and tagging/survival studies for Battle Creek Reintroduction. For the purpose of this RPA, technical assistance is not meant to infer NMFS concurrence with an action, but rather that NMFS is afforded the opportunity to provide scientific or technical recommendations for Reclamation's consideration.

# SD.3.b - Reclamation Shall Provide the Unmet Funding Needs to Complete the Battle Creek Winter-run Chinook Salmon Reintroduction Plan

- a. The unmet funding needs are described in Item #2 in the attachment to the June 19, 2019, letter from FWS to NMFS (Appendix C), and also in Table 15 of the 2016 Battle Creek Winter-run Chinook Salmon Reintroduction Plan, and include:
  - Construction of a fish culture facility on the North Fork of Battle Creek.
  - Additional supporting facilities and capital equipment at the Coleman Weir, such as holding tanks, water chillers, fry capture equipment and fish transport trucks.
  - Annual operations costs for fish culture, power and water and monitoring activities, including, but not limited to data collection and processing, tagging, genetic evaluations.

# SD.3.c – Reclamation Shall Construct a Fish Sorting Facility at the Coleman National Fish Hatchery

- a. Design and construct a fish sorting facility at Coleman National Fish Hatchery (CNFH) to support the Battle Creek monitoring program and restoration and facilitate hatchery operations and evaluation.
- b. Design and implement a strategy to document the benefits of fish sorting on the survival and productivity of all Chinook salmon populations that are impacted by the sorting.

Rationale: In the PA, Reclamation proposed to accelerate the Battle Creek Restoration Program but did not provide any details about how this would be accomplished. The USFWS provided additional detail in a letter dated June 19, 2019, on the status, including funding certainty, of hatchery-related actions, including those necessary for Battle Creek reintroduction. Beginning in 2017, early implementation of the winter-run Chinook salmon reintroduction was initiated through the Winter-run Chinook Salmon Reintroduction Jump-start Project. In 2019, CDFW and USFWS executed a funding agreement to fund initial stages of the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. Accelerating the Battle Creek Restoration Program will increase habitat availability for winter- and spring-run Chinook salmon and CCV steelhead that will contribute to improvements in their spatial, genetic and life-history diversity, abundance and growth rates.

### SD.4 - Middle and Lower Sacramento River Habitat Restoration

**Objective:** To restore and enhance floodplain, side-channel and in-channel habitat for salmon and steelhead in order to improve the growth and survival of emigrating juveniles

**SD.4.a** – Reclamation shall develop and implement a middle and lower Sacramento River Habitat Restoration Plan.

- a. The goal of the Habitat Restoration Plan shall be to restore at least 2,000 acres of mainstem Sacramento floodplain and side-channel habitat.
- b. The draft plan shall be developed and submitted to NMFS for review by December 31, 2021. The plan shall include proposed actions and locations and a funding and implementation strategy.
- c. A final plan shall be completed by June 1, 2022.
- d. Actions may be taken as soon as possible but shall begin no later than July 2020, prior to completion of the final plan.
- e. NMFS understands and expects that these projects will be partially or wholly funded by public funding sources such as the CVPIA program, the PCSRF/FRGP NOAA funds for salmon recovery and or State bond funds (e.g. Prop 1) in addition to PWA funds and other non-state and federal sources. NMFS further understands that each of these funding programs have their own processes, and expects Reclamation, DWR and local sponsors to compete for these funds. Furthermore, NMFS understands that PWAs will apply for funds, and if funded, implement several projects on this list.

# SD.4.b – Reclamation Shall Consult with NMFS and CDFW to Study, Develop and Implement an Eight Year Science-based Predator Hotspot Management Experiment

- a. The draft experimental design shall be developed and submitted to NMFS for review by December 31, 2021. The plan shall include proposed actions and locations and a funding and implementation strategy.
- b. NMFS WCR and NMFS SWFSC shall be consulted on the experimental design, including the objectives, scope, locations, timing, questions/hypotheses, and methods.
- c. A final plan shall be completed by June 1, 2022.
- d. Actions may be taken as soon as possible but shall begin no later than July 2022.
- e. Reports summarizing the effectiveness of the experiment are due by July 2025, and July 2030.

# SD.5 – Reclamation Shall Provide the Unmet Funding Needs to Improve Livingstone Stone National Fish Hatchery

**Objective:** Ensure that funding applied to hatchery improvements that are necessary to support the winter-run Chinook salmon population Supplementation Program and also actions that may be necessary during Tier 3 and Tier 4 years.

- a. The unmet funding needs are described in Item #1 in the attachment to the June 19, 2019, letter from FWS to NMFS (Appendix C). Reclamation shall:
  - either secure an emergency/alternate water supply when Shasta and Keswick reservoirs reach elevations below the current penstocks, or acquire (either purchase or rent) water chillers to ensure that adequate water temperatures are provided during critical winter-run Chinook salmon life stages (e.g., adult holding, egg incubation, and juvenile rearing).
  - coordinate with NMFS and the USFWS to evaluate the need for modifications or improvements to Keswick Dam Fish Trap and Elevator, or operational

- adjustments to reduce the likelihood of injury or death to adult fish entering or attempting to enter the trap.
- coordinate with NMFS and USFWS to investigate the feasibility of installing an
  alternative winter-run Chinook salmon collection facility on the south side of the
  Sacramento River at the ACID fish ladder. The study shall begin in January 2020.
  If the results of the investigation determine that a collection facility would be
  technically and economically feasible, Reclamation shall install such a facility
  within 2 years of the recommendation.
- coordinate with the USFWS on the need to install a drum screen to remove solids from the hatchery's effluent. The purpose of the drum screen would be to provide more flexibility to use medicated feed to prevent disease. If, at any time, the USFWS determines that such infrastructure is necessary to prevent disease, particularly during Tier 3 and 4 years, Reclamation shall install this infrastructure.

**Rationale:** Due to the variability in the abundance of the naturally-produced winter-run Chinook salmon population in the Sacramento River, the Livingston Stone National Fish Hatchery is used to supplement the abundance of the population. Also, during droughts and as proposed in Tier 4 years, demands on the hatchery are likely to increase. It is necessary to ensure that all of the infrastructure needs are in place to ensure this demand can be met.

# SD.6 – Use of Power Bypasses for Temperature Control

**Objective:** The objective is to ensure that all actions necessary to control water temperatures in the Sacramento River are considered.

 Reclamation shall implement power bypasses when needed for additional cold water resources.

**Rationale:** During certain condition, it may be necessary to use the power bypasses at Shasta and Keswick dams to meet water temperature objectives.

# **American River Division**

Action AR.1 - Preparation of Hatchery Genetic Management Plan (HGMP) for steelhead and fall-run Chinook salmon at the Nimbus Fish Hatchery

**Objective:** Improve genetic and life history diversity of American River steelhead by ensuring the timely completion of the Nimbus HGMP and to reduce the operational hatchery management effects on fall-run Chinook salmon in order to improve prey availability of SRKWs.

# AR.1.a - Reclamation Shall Fund Genetic Screening at the Nimbus Fish Hatchery for Steelhead to Determine the Most Ecologically Appropriate Broodstock Source

a. This action shall be completed by March 31, 2021.

AR.1.b - Reclamation Shall Fund a Study Examining the Potential to Replace the Nimbus Fish Hatchery Steelhead Broodstock, with Genetically More Appropriate Sources.

a. This action shall be completed by March 31, 2022.

AR.1.c - Reclamation Shall Fund Development and Implementation of Plans for Alternative Hatchery Release Strategies and/or Increased Hatchery Production with the Goal of Increasing Survival and Ocean Abundance of Fall-run Chinook Salmon as Part of the Nimbus HGMP for Fall-run Chinook Salmon.

- a. The HGMP should establish a plan for implementing alternative release strategies, as determined appropriate through studies and consultation with NMFS. The HGMP should include plans for documenting the ongoing effectiveness of alternative hatchery release strategies and their impact on Chinook salmon abundance and diversity.
- b. The HGMP should establish a plan for evaluating and implementing increased hatchery production goals in concert with alternative hatchery release strategies.
- c. This action shall be completed by March 31, 2022.

Rationale: Hatcheries have been established on CVP and SWP rivers to offset effects of dams and project operations. Since these hatcheries were initially put into operation, additional knowledge has been developed that has advanced NMFS understanding of how hatchery operations can affect listed and non-listed salmonids. Nimbus Fish Hatchery steelhead broodstock is predominantly Eel River stock. Maintaining this genetic broodstock has adverse effects on listed steelhead in the CCV steelhead DPS (Garza and Pearse 2008). An HGMP is necessary to minimize effects of the ongoing steelhead hatchery program on steelhead contained within the DPS.

Additionally, SRKWs depend on Chinook salmon as prey. Preparation of a hatchery management plan for fall-run Chinook salmon at Nimbus Fish Hatchery is necessary to reduce operational effects on SRKW prey. Improving the genetic diversity and diversity of run timing of Central Valley fall-run Chinook salmon will decrease the potential for localized prey depletions and, thereby, provide a more consistent food source even in years with overall poor productivity.

# AR.2 - Use of Power Bypasses for Temperature Control

**Objective:** The objective is to ensure that all actions necessary to control water temperatures in the American River are considered.

a. Reclamation shall implement power bypasses when needed for additional cold water resources, not just during the limited circumstances (i.e., "Reclamation proposes to limit power bypass operations solely to respond to emergency or unexpected events or during extreme drought years when a drought emergency has been declared by the Governor of California") identified in the PA (Appendix A3)

**Rationale:** During certain conditions, it may be necessary to use the power bypasses at Folsom Dam to meet water temperature objectives.

### **Delta Division**

### Action DD.1 - San Joaquin Basin Steelhead Protections

**Objective:** To reduce the vulnerability of emigrating CCV steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the export facilities due

to the diversion of water by the export facilities in the South Delta by undertaking a suite of flow and non-flow actions.

DD.1.a - Reclamation Shall Initiate an Interim Action 2:1 Inflow to Export Ratio for April and May for the 2021 Water Year Only While the Study Plan Described in DD.1.b, below, is Developed. If an Alternative Study is not Agreed to, then Reclamation Shall Operate to the Following Inflow to OMR Relationship Starting in 2022.

Allowable OMR flows depend on gaged flow measured at Vernalis³², and will be determined by a linear relationship. If Vernalis flow is below 5,000 cfs, OMR flows will not be more negative than -2000 cfs. If Vernalis is 6,000 cfs, OMR flows will not be less than +1000 cfs. If Vernalis is 10,000 cfs, OMR flows will not be less than +2,000 cfs. If Vernalis is 15,000 cfs, OMR flows will not be less than +3,000 cfs. If Vernalis is at or exceeds 30,000 cfs, OMR flows will not be less than + 6,000 cfs.

# DD.1.b – Multi-species March-May Q-west or Vernalis Adaptive Management Program (VAMP)-like Action

- a. Reclamation shall create an interagency workgroup to develop a science-based experimental alternative that provides similar protection to the San Joaquin Inflow-to-Export (I:E) ratio, protects multiple species in Delta during this period, and submit to NMFS for review at a project specific level.
- b. The alternative shall be an adaptive management action that is based on an experimental design with a suite of different action considerations based on variable flow and fishery conditions.
- c. Reclamation shall charter an independent panel consistent with "Chartering of Independent Panels" under the "Governance" section of the final PA (Appendix A3) to review the design and implementation concepts, and adaptive management provisions of the action and shall seek NMFS technical assistance on all recommendations that result from the panel review for consideration.
- d. Reclamation shall seek NMFS technical assistance on workgroup membership, experimental design, and selection of contractor. NMFS shall be invited to co-author annual and final reports.
- Reclamation shall make a long-term investment in tagged fish studies as part of this
  effort.
- f. Reclamation shall seek NMFS concurrence on the action under this section prior to implementation.

DD.1.c – Reclamation Shall Install the Head of Old River Barrier so that it is Operational by April 1st, and During the April and May Period, Whenever Feasible, and Shall Consult with NMFS for Concurrence on Feasible Conditions.

**Rationale:** Existing protections for San Joaquin Basin CCV steelhead are not sufficient and will reduce the spatial diversity, abundance and productivity of the DPS. The modeling conducted for the original PA depicts that OMR flows will become substantially more negative in April and May without the I:E ratio which restricted export rates to a ratio of the inflow of the San Joaquin River as measured at Vernalis during April and May. NMFS expects that, even under the final

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³² When OMR target is based on Vernalis flow, will be a function of 5-day average measured flow.

PA, OMR flows during April and May will likely be more negative in April and May than under current operations, just less so than under the original PA.

Recent modeling (Buchanan 2019) of the effects of the HORB presence on the estimated CCV steelhead survival from the HOR to Chipps Island indicates that survival is higher when the barrier is installed, compared to when it is not installed. Based on NMFS' current understanding of survival probabilities based on barrier condition at the Head of Old River, the PA will lead to lower survival of steelhead juveniles emigrating from the San Joaquin River basin by up to 20 percent for flows between 3,800 cfs and 5,000 cfs at Vernalis.

# **Action DD.2 - SRKW Protections**

**Objective:** To ensure the effects of Delta Operations on all Central Valley salmon populations and overall Chinook salmon productivity are minimized by developing operational loss thresholds for all Chinook salmon populations.

# DD.2.a – Reclamation, in Coordination with NMFS, Shall Develop and Implement Loss Thresholds for Operations at TFCF and SDFPF for all Chinook Salmon Populations in the Central Valley.

The final PA does not include loss thresholds that are specifically protective of all Chinook salmon in the Central Valley, fall-run Chinook salmon in particular. In order to ensure that the effects of Delta operations on the prey availability of Chinook salmon are minimized, Reclamation shall work with NMFS to develop and implement loss thresholds for all Chinook salmon populations, including fall-run, late fall-run, and CV spring-run Chinook salmon, that are at least consistent with the intent of the performance measures designed specifically for winter-run Chinook salmon and CCV steelhead. As part of this process, Reclamation and NMFS may consider a "combined" approach where performance measures for all Chinook salmon in total may achieve the objective of this measure. Loss thresholds for all Chinook salmon populations shall be developed by, and implemented beginning in, Water Year 2020, and may be revised with the review and concurrence of NMFS.

# **East-side Division**

# Action ED.1: San Joaquin Basin Steelhead Protections

**Objective:** To reduce the vulnerability of emigrating CCV steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta by undertaking a suite of flow and non-flow actions.

ED.1.a – Reclamation Shall Implement Floodplain Restoration at the San Luis National Wildlife Refuge and Shall Support the Following Lower San Joaquin River Habitat Projects Consistent with the Collaborative Planning Action described in the PA.

- Franks tract or other San Joaquin corridor specific restoration actions in the southern Delta.
- b. Sturgeon Bend Floodplain Restoration
- c. Durham Ferry State Recreation Area floodplain restoration

Rationale: Existing protections for San Joaquin Basin CCV steelhead are not sufficient and will reduce the spatial diversity, abundance and productivity of the DPS. The RPA actions will increase the growth San Joaquin origin CCV steelhead to improve the likelihood of their survival as they migrate downstream through the lower San Joaquin River and Delta. Juvenile listed salmonids emigrate downstream in the main channel of the San Joaquin River during the winter and spring period. Juvenile CCV steelhead from the San Joaquin River basin, the Calaveras River basin, and the Mokelumne River basin also utilize the lower reaches of the San Joaquin River as a migration corridor to the ocean.

# G.1.- Upon expiration of contracts, Reclamation shall renew contracts to provide linkage to this consultation. Similar to language that has recently been negotiated on American River contracts, Reclamation shall include the following language in contract renewals:

"This contract is subject to the requirements of the Endangered Species Act (ESA) and all other applicable laws. The Contractor shall operate in accordance with all requirements of any applicable biological opinion(s) in effect during the term of this Contract, including but not limited to all biological opinions for the joint operations of the Central Valley Project and the State Water Project. The Contracting Officer and the Contractor acknowledge and agree that Reclamation also must act in accordance with the requirements of the ESA, including any shortages or operational restrictions necessary to comply with applicable biological opinions."

**Rationale**: Past practices have occasionally created confusion over the linkage between the biological opinion and individual contracts. This provision will clarify the legal mechanism by which contracts receive coverage under this biological opinion or its successor.

# 2.10.2 RPA Consistency with the Proposed Action

The purpose and need for modifications to the long-term operation of the CVP and SWP (Projects) is to operate the Projects in a manner than enables Reclamation and DWR to maximize water deliveries and optimize marketable power generation consistent with applicable laws, contractual obligation, and agreements; and to augment operational flexibility by addressing the status of listed species (82 FR 61790, Dec. 29. 2017). The RPA is consistent with the intended purpose of the action because it builds on concepts and policies already proposed in the action. According to the BA, "[t]he proposed action is the continued operation of the CVP and SWP." Specifically, Reclamation and DWR propose to operate the CVP and SWP to divert, store, and convey CVP and SWP water consistent with applicable law and contractual obligations. Changes in operation of the Projects to avoid jeopardizing listed species or adversely modifying their critical habitats require that additional sources of water for the Projects be obtained, or that water delivery be made in a different way than in the past or that amounts of water that are withdrawn and exported from the Delta during some periods in some years be reduced. These operational changes do not, however, preclude operation of the Projects.

NMFS developed focused actions considering the full range of authorities that Reclamation and DWR may use to implement these actions. These authorities are substantial. The CVPIA, in particular, makes "mitigation, protection, and restoration of fish and wildlife" authorized purposes of the Central Valley Project and provides Reclamation with ample authority to provide benefits for fish and wildlife through measures such as purchasing water to augment in-stream flow, implementing habitat restoration projects, and taking other beneficial actions.

# 2.10.3 Consistency with the Scope of the Federal Agency's Legal Authority and Jurisdiction, that is Economically and Technologically Feasible

The RPA can be implemented consistent with the scope of the federal agency's legal authority and jurisdiction. The Rivers and Harbors Act of 1937, which established the purposes of the CVP, provided that the dams and reservoirs of the CVP "shall be used, first, for river regulation, improvement of navigation and flood control; second, for irrigation and domestic uses; and, third, for power." (ROC on LTO BA, p. 1-2). The CVP was reauthorized in 1992 through the CVPIA, which modified the 1937 Act and added mitigation, protection, and restoration of fish and wildlife as project purposes. The CVPIA provided that the dams and reservoirs of the CVP should be used "first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses and fish and wildlife mitigation, protection and restoration purposes; and, third, for power and fish and wildlife enhancement." (ROC on LTO BA p. 1-3) One of the stated purposes of the CVPIA is to address impacts of the CVP on fish and wildlife. CVPIA, Sec. 3406(a). The CVPIA gives Reclamation broad authority to mitigate for the adverse effects of the projects on fish and wildlife, and nothing in the Rivers and Harbors Act of 1937 requires any set amount of water delivery.

In addition to adding protection of fish and wildlife as second tier purposes of the CVP, the CVPIA set a goal of doubling the natural production of anadromous fish in Central Valley rivers and streams on a long-term sustainable basis, by 2002. Sec. 3406(b)(1). This goal has not been met. Instead, as detailed in this opinion, natural production of anadromous fish has declined precipitously. A 2008 report on the CVPIA anadromous fish program by independent reviewers (Cummins *et al.* 2008), recommended by the Office of Management and Budget and requested by Reclamation and the USFWS, stated that:

[The agencies] "should develop a more expansive view of the authorities at their disposal to address the problems, especially with regard to water management and project operations. The agencies have followed a more restrictive view of their authorities than appears legally necessary or appropriate to the seriousness of the mission."

Most relevant to this consultation, the review panel observed that:

"[i]t would seem that CVPIA activities and personnel should be central to the OCAP plan, the Section 7 consultation, and the agencies' efforts to satisfy the requirements of the ESA (that is, after all, one of the directives of the CVPIA). The panel received no information or presentations on the involvement of the CVPIA program or personnel in the ESA consultation effort . . . and in the determination of what actions the agencies should be taking to meet the ESA."

Reclamation and DWR operate their respective projects in close coordination, under a Coordinated Operations Agreement (COA). The COA was authorized by Congress in Public Law 99-546. Consequently, the COA "is the federal nexus for ESA section 7 consultation on operation of the SWP. Because of commitments expressed in the COA and the Congressional mandate to Reclamation to operate the CVP in conjunction with the SWP, the operations of the two projects are linked…"

DWR, like Reclamation, has broad authority to preserve and enhance fish and wildlife. State law gives DWR authority to provide for needs of fish and wildlife independent of the connection of the two water projects.

[DWR] "is required to plan for recreational and fish and wildlife uses of water in connection with State-constructed water projects and can acquire land for such uses (Wat. Code Sec. 233, 345,346, 12582). The Davis-Dolwig Act (Wat. Code Sec. 11900-11925) establishes the policy that preservation of fish and wildlife is part of State costs to be paid by water supply contractors, and recreation and enhancement of fish and wildlife are to be provided by appropriations from the General Fund."

The Preamble to the ESA consultation regulations states that "a Federal agency's responsibility under section 7(a)(2) permeates the full range of discretionary authority held by that agency," and that the Services can prescribe a RPA "that involves the maximum exercise of Federal agency authority when to do so is necessary, in the opinion of the Service, to avoid jeopardy." 51 Fed. Reg. 19925, 19937 (June 3, 1986). The independent review panel concluded that despite Congressional authorization and direction more than 16 years ago to restore anadromous fish populations in Central Valley rivers and streams, Reclamation continues to take an unduly narrow view of its authorities in carrying out Congress' mandate. The legal foundation of this RPA is a broader view of Reclamation's authorities, one that is consistent with the CVPIA, the ESA, and the independent review panel's recommendations.

# **Project Costs**

In addition to water costs, Reclamation and DWR will incur project costs associated with certain RPA actions (*e.g.*, the fish passage program). The State of California has authorized over 20 billion in water-related general obligation bonds since 2000, and these bonds often contain provisions for environmental conservation related purposes (LAO, 2008). Similarly, the CVPIA AFRP funds eligible restoration projects, using federal authorities. Some of the projects in the RPA may qualify for those sources of funds. Additionally, Reclamation and DWR signed an MOU in December 2018 providing for funding to implement the NMFS 2009 opinion, including the RPA actions, which shows they have the resources, capacity and authority to implement a complex RPA, including the ability to recover costs from water contractors, if necessary. Although NMFS has not had time to complete a thorough economic analysis, given the scope of the NMFS 2009 opinion RPA (72 RPA actions), as compared to the scope of this RPA, the actions contained in this RPA are not more costly than those actions, and are likely less costly both in terms of water and dollars.

# 2.10.4 Avoids the Likelihood of Jeopardizing the Continued Existence of Listed Species or Resulting in the Destruction or Adverse Modification of Critical Habitat

This section presents NMFS' rationale for concluding that with adoption of this RPA, Reclamation would avoid jeopardizing the listed species and adversely modifying their designated critical habitats. This rationale is presented for the following species and critical habitats that NMFS concluded would be jeopardized or adversely modified by the proposed action:

Sacramento River winter-run Chinook salmon and its designated critical habitat,

- CV spring-run Chinook salmon and its designated critical habitat,
- CCV steelhead and its designated critical habitat, and
- Southern Resident killer whales

Each section summarizes the main stressors and the actions within the RPA that alleviate those stressors. The supporting biological information for each action is contained in the "objective" and "rationale" sections for each RPA action. Each action of the RPA is linked to at least one main stressor for at least one species, identified in the effects analysis and the integration and synthesis sections of this opinion.

# Sacramento River Winter-Run Chinook Salmon and its Designated Critical Habitat

Throughout this opinion, NMFS has explained that a species' viability (and conversely extinction risk) is determined by the VSP parameters of spatial structure, diversity, abundance, and productivity. In addition, NMFS has explained the need for the proper functioning of the PBFs that comprise the critical habitat designation.

Currently, only the one small population of winter-run Chinook salmon spawning downstream of Keswick Dam exists, making this species particularly vulnerable to environmental pressures such as the 2012-2015 drought. This vulnerability manifested with the drought as three consecutive year classes suffered heavy losses due to an inability to release cold water from Shasta Reservoir throughout the egg and fry life stages. Warm water releases from Shasta Reservoir contributed to egg-to-fry mortality rates of 85 percent in 2013, 94 percent in 2014, and 96 percent in 2015, the highest levels since estimates of that statistic began in 1996. Mortality decreased after the drought ended with 76 percent mortality in 2016 and 56 percent mortality in 2017.

The Sacramento River winter-run Chinook salmon ESU is at high extinction risk because there is only one naturally-spawning population, and it is not within its historical range (Lindley et al. 2007, National Marine Fisheries Service 2016c). Of over 165 species that NMFS protects under the Endangered Species Act, the winter-run Chinook salmon ESU is considered one of just nine³³ species that are most at risk of extinction in the near future, per the Species in the Spotlight initiative (National Marine Fisheries Service 2015e).

As described in the Status of the Species section of this Opinion, weaknesses in all four VSP parameters -- spatial structure, population size, population growth rate, and diversity -- contribute to this risk. In particular: (1) multiple populations of this ESU have been extirpated; the ESU now is composed of only one population, and this population has been blocked from all of its historical spawning habitat; (2) habitat destruction and modification throughout the mainstem Sacramento River have dramatically altered the ESU's spatial structure and diversity; (3) the ESU is at risk from catastrophic events including drought; (4) the population has a "high" hatchery influence (Lindley *et al.* 2007); and (5) the population experienced an almost seven fold decrease in 2007. In addition, many of the physical and biological features of critical habitat that are essential for the conservation of winter-run are currently impaired and provide limited habitat value.

The extinction risk of the winter-run Chinook salmon population has increased since the 2007 assessment. Based on the Lindley et al. (2007) criteria, the population is at high extinction risk in 2019. High extinction risk for the population was triggered by the hatchery influence criterion,

³³ The NMFS Species in the Spotlight initiative was initially launched highlighting eight species most in need of urgent protection; a ninth species was added in 2019.

with a mean of 66 percent hatchery origin spawners over the last generation from 2016 through 2018. The threshold for high risk associated with hatchery influence is 50 percent hatchery origin spawners.

The PA increases the population's extinction risk and continues to degrade the PBFs of critical habitat by adding numerous stressors to the species' baseline stress regime, as is generally described in the *Integration and Synthesis* section of the Opinion. The RPA specifies several actions that will reduce the adverse effects of the proposed action on winter-run and its critical habitat.

The RPA actions specifically address key project-related factors or threats facing the ESU and its critical habitat including:

- High levels of temperature dependent egg mortality and total mortality in the upper Sacramento River.
- Reduced spatial, life history and genetic diversity.
- Low in-river survival of emigrating smolts caused by seasonal operations that reduce
  river flows in the fall, winter and spring months that expose fish to poor growth condition
  (reduced access to side-channel and floodplain habitat) and increase fish to high levels of
  predation.

Adverse effects of project operations to winter-run Chinook salmon will be reduced primarily through the following measures:

- Using supplemental, science-based temperature dependent and egg-to-fry survival objectives that will be used to reducing temperature dependent egg mortality and egg to fry mortality is necessary to avoid an appreciable reduction in survival and recovery of the species by creating management objectives that support population-scale viability for winter-run Chinook salmon below Shasta and Keswick dams. These objectives will help ensure that the single existing population of endangered winter-run Chinook salmon will persist. RPA action SD.1 addresses the abundance and production criteria and may increase growth rate and abundance over time. SD.6 also helps with water temperature management under certain conditions that will protect incubating eggs from certain conditions that require rapid operational flexibility. This RPA action will also address the adverse modification of the PA on spawning and rearing PBFs of critical habitat by improving their biological function.
- 2) Reinitiating a pilot project to reintroduce winter-run Chinook salmon to their historic habitats upstream from Shasta Dam. RPA action SD.2 addresses the abundance and production criteria, diversity criteria (spatial, genetic and life history) and the growth rate and abundance criteria. This RPA action will also address the adverse modification of the PA on spawning and rearing PBFs of critical habitat by expanding the range of the species to areas where habitat conditions (although not designated as critical habitat) are more favorable to spawning and rearing life stages of the ESU.
- 3) RPA action SD.3 ensures that the Battle Creek Restoration Program and the Battle Creek winter-run re-introduction program will proceed in a timely fashion and that facilities and monitoring are in place to ensure the program is successful. This Battle Creek program is critical in creating an additional population of winter-run Chinook salmon. This additional population increases the species spatial structure and diversity and should increase growth rate and abundance over time. This RPA action will also address the

- adverse modification of the PA on spawning and rearing PBFs of critical habitat by improving their biological function.
- 4) RPA action SD.4 for habitat restoration and predation hot-spot removal ensures that winter-run Chinook salmon rearing habitat actions in the lower Sacramento River and Northern Delta will minimize adverse effects of seasonal project operations and low-flow conditions on winter-run Chinook salmon and their critical habitat. These habitat actions will increase the survival and growth rates of individuals that utilize this habitat. These fish are predicted to enter the estuary and ocean with a higher degree of fitness, and therefore, greater resiliency to withstand stochastic events in these later phases of their life history, thereby increasing the viability of the ESU and reducing the likelihood of appreciable reductions in the survival or recovery of the species. This RPA action will also address the adverse modification of the PA on rearing PBFs of critical habitat that occur from seasonally managed low flow conditions by improving the biological function of the rearing and migratory corridor.

NMFS believes the PA, as modified by actions in this RPA, would avoid the likelihood of jeopardizing the continued existence of winter-run Chinook salmon or resulting in the destruction or adverse modification of its critical habitat.

# Central Valley Spring-Run Chinook Salmon and Its Designated Critical Habitat

As previously stated in the Status of the Species section, the spring-run ESU is currently likely to become endangered within the foreseeable future due to multiple factors affecting spatial structure, diversity, productivity and abundance. Specific factors include: (1) the ESU currently has only three independent populations. All three of these independent populations are in one diversity group, the Northern Sierra Nevada Diversity Group, and the other diversity groups contain dependent populations; (2) habitat elimination and modification throughout the Central Valley have drastically altered the ESU's spatial structure and diversity; (3) the ESU has a risk associated with catastrophes, especially considering the remaining independent populations' proximity to Mt. Lassen and the probability of a large scale wild fire occurring in those watersheds (Lindley *et al.* 2007); (4) the presence of dams precludes access to historical spawning areas; and (5) for some populations, the genetic diversity of spring-run Chinook salmon has been compromised by hybridization with fall-run Chinook salmon.

The effects of the PA on spring-run Chinook salmon are contained in the sections of the opinion on project effects and integration and synthesis. The effects are presented for the Clear Creek population, the mainstem Sacramento River population and for the other populations that are affected by project operations, by diversity group. Ultimately all spring-run Chinook salmon must migrate through the Sacramento River and the Delta, and are affected by Delta operations, particularly low flow conditions related to seasonal operations and exposure to increased export rates in April and May. In the Integration and Synthesis section of this opinion, NMFS described that a species' viability (and conversely extinction risk) is determined by meeting certain VSP criteria for spatial structure, diversity, abundance, and productivity, and more specifically, describes how the PA influences these criteria and affects the likelihood of the species survival and recovery. The RPA actions for CV spring-run Chinook salmon address PA-related effects to these criteria. In addition, NMFS acknowledged the need for the proper functioning of the PBFs that comprise the critical habitat designation.

The RPA actions specifically address key project-related factors or threats facing the ESU and its critical habitat, including:

- Exposure to suboptimal water temperatures during spawning and egg incubation in Clear Creek
- Spawning habitat availability, flow conditions, reduced access to riparian habitat and instream cover, loss of natural river morphology and function
- Low in-river survival of emigrating smolts caused by seasonal operations that reduce river flows in the fall, winter and spring months that expose fish to poor growth condition (reduced access to side-channel and floodplain habitat) and increase fish to high levels of predation.
- Delayed migration and increased transit times related to Delta entrainment with potential
  for increased mortality, along with uncertain/poor in-Delta and through-Delta rearing and
  survival conditions for young-of-year spring-run Chinook salmon in some years and
  conditions due to both project related and non-project related stressors.

Adverse effects of project operations to CV spring-run Chinook salmon will be reduced primarily through the following measures:

- 1) RPA action SD.3 ensures that the Battle Creek Restoration Program will proceed in a timely fashion and that facilities and monitoring are in place to ensure the program is successful. The project is critical to improve the resiliency of CV spring-run Chinook salmon to operations effects of the PA and will increases the species spatial structure and diversity and should increase growth rate and abundance over time. This RPA action will also address modification to critical habitat caused by the action on spawning and freshwater rearing and migration PBFs of critical habitat by increasing the amount of habitat on Battle Creek and improving the function of restored habitats.
- 2) RPA action SD.4 for habitat restoration and predation hot-spot removal ensures that spring-run Chinook salmon rearing habitat actions in the lower Sacramento River and Northern Delta will minimize adverse effects of seasonal project operations and low-flow conditions on spring-run Chinook salmon and its critical habitat. These habitat actions will increase the survival and growth rates of individual CV spring-run Chinook salmon that utilize this habitat. These fish are predicted to enter the estuary and ocean with a higher degree of fitness, and therefore, greater resiliency to withstand stochastic events in these later phases of their life history, thereby increasing the viability of the ESU and reducing the likelihood of appreciable reductions in the survival or recovery of the species. This RPA action will also address modification to critical habitat caused by the action on freshwater rearing and migration PBFs of critical habitat.
- 3) RPA actions CC.1 and CC.2 will enable better forecasting and planning for Clear Creek to provide protective water temperatures for CV spring-run Chinook salmon during holding, spawning, and egg incubation, including evaluation of structural improvements to Whiskeytown Dam to improve cold-water pool availability. The long-term flow and water temperature plan in RPA action CC.3 will help to optimize ecological functions in Clear Creek. These RPA actions will also address modification to critical habitat in Clear Creek caused by the action on freshwater rearing and migration PBFs of critical habitat.
- 4) The RPA actions for CCV steelhead, DD.1.a and DD.1.b, will also minimize in Delta effects to young-of-year spring-run Chinook salmon. These actions are predicted to

improve survival for the proportion of these fish that are present in the central and south Delta in April and May, and increase the proportion of fish that successfully emigrate past Chipps Island. This RPA action will also address modification to critical habitat caused by the action on freshwater rearing and migration PBFs of critical habitat.

NMFS believes the PA, as modified by actions in this RPA, would avoid the likelihood of jeopardizing the continued existence of CV spring-run Chinook salmon or resulting in the destruction or adverse modification of its critical habitat.

# California Central Valley Steelhead and Its Designated Critical Habitat

The PA increases the extinction risk of CCV steelhead and continues to degrade the PBFs of critical habitat by adding numerous stressors to the species' baseline stress regime and reducing the viability of all of the extant CCV steelhead populations, particularly in the Sacramento River, the American River and the San Joaquin Basin. Throughout this opinion, NMFS acknowledged that a species' viability (and conversely extinction risk) is determined by the VSP parameters of spatial structure, diversity, abundance, and productivity. In addition, NMFS acknowledged the need for the proper functioning of the PBFs that comprise the critical habitat designation.

The RPA specifies actions will minimize the adverse effects of the PA on individual CCV steelhead, populations and the DPS and bring about the proper functioning of PBFs of its critical habitat. All actions that address CCV steelhead in the RPA are necessary to minimize project effects to the extent where they do not appreciably reduce the likelihood of survival and recovery of the DPS or adversely modify CCV steelhead critical habitat. This analysis summarizes some of the most significant RPA actions that NMFS relied on in its analysis.

The RPA actions specifically address key project-related factors or threats facing the CCV steelhead DPS and its critical habitat, as described in the "Objectives" and "Rationale" parts of the actions including:

- Spawning habitat availability, flow conditions, reduced access to riparian habitat and instream cover, loss of natural river morphology and function
- Low in-river survival of emigrating smolts caused by seasonal operations that reduce river flows in the fall, winter and spring months that expose fish to poor growth condition (reduced access to side-channel and floodplain habitat) and increase fish to high levels of predation.
- Reduced genetic diversity in the American River.
- Altered hydrodynamics and routing effects in south Delta that reduce through-Delta survival, particularly in April and May to populations comprising the Southern Sierra Diversity Group of the DPS.

Adverse effects of project operations to CCV steelhead will be reduced primarily through the following measures:

1) RPA action DD.1 for Delta and East-side flow and export action, and HORB and habitat actions, and ED.1 for lower San Joaquin habitat restoration, are predicted to create more suitable flow and non-flow related habitat conditions throughout the lower San Joaquin and South Delta that will minimize effects on juvenile CCV steelhead emigrating from the Southern Sierra diversity group and contribute to their growth and survival. The continued existence of this diversity group contributes to the spatial structure and

- therefore viability of the DPS as a whole. This RPA action will also address modification to critical habitat caused by the action on freshwater rearing and migration PBFs of critical habitat.
- 2) RPA action SD.3 ensures that the Battle Creek Restoration Program will proceed in a timely fashion and that facilities and monitoring are in place to ensure the program is successful. This will help reduce effects to the DPS that occur downstream of Shasta and Keswick dams in the upper Sacramento River that reduce spawning habitat availability, flow conditions, reduced access to riparian habitat and instream cover, loss of natural river morphology and function. The project is critical to improve the resiliency of CCV steelhead to operations effects of the PA and will increases the species spatial structure and diversity and should increase growth rate and abundance over time. This RPA action will also address modification to critical habitat caused by the action on spawning and freshwater rearing and migration PBFs of critical habitat by increasing the amount of habitat on Battle Creek and improving the function of restored habitats.
- 3) RPA action SD.4.a for habitat ensures that habitat actions in the lower Sacramento River and Northern Delta will minimize adverse effects of seasonal project operations and low-flow conditions CCV steelhead and their critical habitat. These habitat actions will increase the survival and growth rates of individuals that utilize this habitat. These fish are predicted to enter the estuary and ocean with a higher degree of fitness, and therefore, greater resiliency to withstand stochastic events in these later phases of their life history, thereby increasing the viability of the DPS and reducing the likelihood of appreciable reductions in the survival or recovery of the species. This RPA will also address modification to critical habitat caused by the action on freshwater rearing and migration PBFs of critical habitat.
- 4) The HGMP action (RPA action AR.1) will restore genetic diversity of CCV steelhead in the American River which should help improve life-history diversity in the basin. This action will not influence the condition of critical habitat.

NMFS believes the PA, as modified by actions in this RPA, would avoid the likelihood of jeopardizing the continued existence of CCV steelhead or resulting in the destruction or adverse modification of its critical habitat.

# Southern Resident Killer Whales

NMFS evaluated effects of the PA on SRKW by evaluating effects on the availability of their preferred prey, Chinook salmon. In this opinion, NMFS determined that the PA increases the extinction risk of SRKW by reducing Chinook salmon productivity in the Central Valley, especially for non-listed fall-run Chinook salmon, thereby reducing the available Chinook salmon prey resources for SRKW and increasing the risks of reduced survival and reproduction of SRKW individuals. Given the highly endangered status of this population, reduced survival or reproductive potential for individuals of this population increases the extinction risk and limits the recovery potential of the species.

The RPA actions specifically address the key project-related factors that are diminishing the productivity of Chinook salmon in the Central Valley, including:

 Reduced survival of juvenile Chinook salmon in upstream areas throughout the Central Valley, especially fall-run Chinook salmon, resulting from temperature and flow related

- impacts that affect or limit the productivity of available habit for Chinook salmon in the Central Valley.
- Altered hydrodynamics and routing effects in south Delta that reduce through-Delta survival for all Chinook salmon populations.
- Increased extinction risks for ESA-listed Chinook that could further diminish the
  productive capacity of the Central Valley and diversity of Chinook salmon prey resources
  available of SRKW.

Adverse effects of project operations to SRKW will be reduced primarily through the following measures:

- Accelerating the Battle Creek Restoration Program will increase habitat availability for and productivity of winter- and spring-run Chinook, which improves the overall productivity of Chinook salmon in the Central Valley increasing the number of juvenile Chinook salmon that survives to the ocean as potential prey for SRKW.
- 2) The RPA action for habitat restoration and predation hot-spot removal ensures that Chinook salmon rearing habitat actions in the lower Sacramento River and Northern Delta will minimize adverse effects of seasonal project operations and low-flow conditions on Chinook salmon. These habitat actions will increase the survival and growth rates of individuals that utilize this habitat. These fish are predicted to enter the estuary and ocean with a higher degree of fitness, and therefore, greater resiliency to withstand stochastic events in these later phases of their life history, thereby increasing the Chinook salmon prey resources available for SRKW over time.
- 3) Preparation of an HGMP for fall-run Chinook salmon at Nimbus Fish that evaluate and implement appropriate alternative release strategies and increased hatchery production goals for fall-run Chinook salmon is necessary to reduce operational effects on Southern Residents prey by increasing the number of juvenile Chinook salmon that survives to the ocean as potential prey for SRKW. The HGMP should also improve the genetic diversity and diversity of run timing of Central Valley fall-run Chinook salmon which will decrease the potential for localized prey depletions and thereby provide a more consistent food source for SRKW.
- 4) The RPA action to use the power bypasses at Keswick Dam and Folsom Dam to meet water temperature objectives helps ensure that all actions necessary to control water temperatures to protect and promote salmon productivity in these rivers are considered. This action will help minimize temperature effects on juvenile Chinook salmon increasing the number of juvenile Chinook salmon that survives to the ocean as potential prey for SRKW.
- 5) The RPA actions for CCV steelhead in DD.1.a and DD.1.b will also minimize in Delta effects to Chinook salmon young-of-year, including fall-run and CV spring-run Chinook salmon. This action will improve survival for the proportion of these fish that are present in the central and south Delta in April and May, and increase the proportion of fish that successfully enter the ocean as potential prey for SRKW.
- 6) The RPA action to develop and implement loss thresholds for all Central Valley Chinook salmon population will address reduced juvenile Chinook salmon survival and overall productivity of Chinook salmon in the Central Valley by ensuring that the effects of Delta Operations on all Central Valley salmon populations are minimized. This action will help increase the available Chinook salmon prey resources for SRKW over time.

- 7) The RPA actions for Delta and East-side flow and export actions along with the habitat actions, are predicted to create more suitable flow and non-flow related habitat conditions throughout the lower San Joaquin and South Delta that will minimize effects on juvenile Chinook salmon. This action will help increase the available Chinook salmon prey resources for SRKW over time.
- 8) Implementation of all RPA actions for ESA-listed Chinook salmon will allow the PA to proceed without jeopardizing any Chinook salmon ESUs, which will prevent further diminishment of the productive capacity of the Central Valley and the diversity of Chinook salmon prey resources available of SRKW.

Because this biological opinion has found jeopardy and destruction or adverse modification of critical habitat, Reclamation is required to notify NMFS of its final decision on the implementation of the RPA.

# 2.11 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

An ITS is not required for a framework programmatic action, i.e., an action "that approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time, and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further section 7 consultation" (50 CFR 402.02, 402.14(i)(6)). For a mixed programmatic PA, an ITS is required only for those program actions that are reasonably certain to cause take and are not subject to further section 7 consultation (50 CFR 402.14(i)(6)). A mixed programmatic PA is defined as, "for the purposes of an [ITS], a Federal action that approves action(s) that will not be subject to further section 7 consultation, and also approves a framework for the development of future action(s) that are authorized, funded, or carried out at a later time and any take of a listed species would not occur unless and until those future action(s) are authorized, funded, or carried out and subject to further section 7 consultation" (50 CFR 402.02). However, if an action agency designs a programmatic action or a mixed programmatic action that approves a framework for development of future action(s) that are authorized, funded, or carried out at a later time, and provides adequate information to inform the development of a biological opinion with an ITS related to future actions implemented under the program, NMFS may be able to include an ITS related to such an action if it determines that the action is reasonably certain to cause incidental take of listed species. This Opinion assesses the effects of the PA. Based on these assessments, NMFS determined that the PA is reasonably certain to result in incidental take of listed species as

described in Section 2.11.1 Amount or Extent of Anticipated Take. Incidental take for PA components identified as framework-level, are not included in this ITS (see 2.1.1 and Table 2.11-1).

Table 2.11-1. Programmatic actions considered in the effects and I&S sections at the framework-level, therefore no exemptions from take prohibitions provided in this ITS.

Division	PA component
	Lower Intakes near Wilkins Slough
	Spawning Gravel Injection ^a
	Side Channel Habitat Restoration ^a
Shasta-Sacramento River	Small Screen Program
	Adult Rescues (Intervention)
	Juvenile Trap and Haul (Intervention)
	Battle Creek Restoration ^a
	LSNFH Production (Intervention)
Trinity-Clear Creek	Mechanical Channel Maintenance
American	<ul> <li>Spawning and Rearing Habitat Restoration^a</li> <li>Gravel augmentation and floodplain work</li> <li>Cordova Creek Phase II and Carmichael Creek Restoration projects</li> <li>Maintenance activities at Nimbus Basin, Upper Sailor Bar, and River Bend restoration sites</li> </ul>
	Construction of Spawning and Rearing Habitat ^a
East Side	Temperature Management Study ^b
	Lower SJR Habitat
	Sacramento Deep Water Ship Channel Food Study
	North Delta Food Subsidies/ Colusa Basin Drain
	Suisun Marsh Roaring River Distribution System Food Subsidies Study
Delta	Tidal Habitat Restoration
	Predator Hot Spot Removal
	San Joaquin Basin Steelhead Telemetry Study ^b

^a Incidental take coverage may already be exempted in separate biological opinions

Under the MMPA "take" means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal. The definition of harassment includes any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild; or has the potential to disturb a marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing,

^b Incidental take of ESA-listed species under NMFS jurisdiction may not occur for these actions, in which case they may proceed without further consultation with NMFS.

breeding, feeding, or sheltering. Under the ESA, "take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102).

In this Opinion we have identified ESA take in the form of harm to SRKWs through reduction of their prey. This is an indirect effect. The MMPA definition of harassment includes any act of pursuit, torment, or annoyance which: (1) has the potential to injure a marine mammal or marine mammal stock in the wild; or (2) has the potential to disturb a marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. ESA take in the form of harm due to prey reduction identified in this opinion and subsequent Incidental Take Statement does not take the form of MMPA harassment as described above in this paragraph, and as such there is no corresponding MMPA authorization required for this form of take.

### 2.11.1 Amount or Extent of Take

In the Opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

Incidental take of endangered winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, threatened sDPS green sturgeon, and endangered SRKW will occur as a result of implementing the CVP/SWP operations, as described in Appendix A3 of this Opinion. Reservoir operations are expected to continue to alter the natural hydrological cycle (i.e., releases that are higher in the summer than flows which occurred before the dams were built and releases in the spring which are lower than flows occurring during the spring before the dams were built) in the Sacramento River downstream of Keswick Dam, in Clear Creek downstream of Whiskeytown Dam, in the American River downstream of Folsom Dam, and in the Stanislaus River downstream of New Melones Dam.

This ITS uses surrogates to establish the expected level of incidental take due to the PA when direct quantification of take of individuals is not possible to determine. It is not practical to quantify or track the amount or number of individuals that are expected to be incidentally taken per species as a result of the PA due to the variability associated with the response of listed species to the effects of the PA, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing injured or dead fish. However, it is possible to estimate the extent of incidental take by designating an ecological surrogate(s), and it is practical to quantify and monitor the surrogate(s) to determine the extent of incidental take that is occurring. This ITS explains the causal link between the surrogate and take of the listed species; and establishes a clear standard for determining when the level of anticipated incidental take is exceeded (the surrogate parameter).

Table 2.11.1-1 through Table 2.11.1-4, below, describe the amount or extent of take by listed species, life history stage, stressor, and location within the action area. The sections that follow the tables, organized by type of activity within the PA, specify an amount of take where possible (i.e., impingement and entrainment of juveniles, fish salvage estimates), but otherwise, specify a geographic and temporal extent of take.

# **Administration of Water Supply Contracts**

This consultation addresses the long-term operations of the CVP and SWP, including the overall impacts of the total volume of water diverted from the Central Valley (e.g., higher summer flows, lower spring flows, water temperature, etc.). The volume of water delivered may be reduced from full contract amounts, consistent with the terms of individual contracts. In addition, take from the administration of water transfers is included in CVP/SWP operations for this consultation. However, this consultation does not address ESA section 7(a)(2) compliance for individual water supply contracts, except for the Sacramento River Settlement Contracts. Reclamation and DWR should consult with NMFS separately on their issuance of individual water supply contracts, including analysis of the effects of reduced water quality from agricultural and municipal return flows, contaminants, pesticides, altered aquatic ecosystems leading to the proliferation of non-native introduced species (i.e., warm-water species), or the facilities or activities of parties to agreements with the U.S. that recognize a previous vested water right.

# 2.11.1.1 Winter-run Chinook Salmon Incidental Take Table

Table 2.11.1-1. Winter-run Chinook Salmon Incidental Take

Sacramento Shasta: Tier 2 (Shasta Summer Cold Water Pool Management.)	Upper Sacramento Shasta: Tier 1 (Shasta Summer Cold Water Pool Management)	Action Component (by division)
Water Temperature under Tier 2 management Eggs/Fry (Keswick Dam - CCR gauge)	Water Temperature under Tier 1 management Eggs/Fry (Keswick Dam - CCR gauge)	Stressor and Life Stage (location)
May - October (May 15 – October 31)	May - October (May 15 - October 31)	Life Stage Timing (Work Window Intersection)
Ніф	High	Magnitude of Effect
High: Supported by multiple scientific and technical publications that include quantitative models specific to the region and species.	High: Supported by multiple scientific and technical publications that include quantitative models specific to the region and species.	Weight of Evidence
Reduced survival probability (12% - 15% temperature dependent mortality).	Reduced survival survival ypobability (5% - 6% temperature dependent mortality).	Probable Change in Fitness
Lethal: Temperatures higher than 53.5°F would result in reduced survival (mean temperature-dependent mortality of 12 percent [Anderson] and 15 percent [Martin]; the standard deviations are +/- 13 percent [Anderson] and +/- 16 percent [Martin]).	Lethal: Temperatures higher than 53.5°F would result in reduced survival (mean temperature-dependent mortality of 5 percent [Anderson] and 6 percent [Martin]; the standard deviations are +/- 8 percent [Anderson] and +/- 9 percent [Martin]).	Type of Incidental Take
Ecological surrogates related to Shasta Summer Cold Water Pool Management:  The extent of incidental take is the spawning habitat that exceeds 53.5°F in Tier 2 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  Shasta operations will remain consistent with allowable tolerances.  Shasta operations will remain consistent with allowable tolerances.  Shasta operations will remain consistent with Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).  No more than two consecutive years in which winter-run Chinook salmon, ETF survival is less than 15%, and where measures must be taken to achieve ETF survival of at least 15% for the third	Ecological surrogates related to Shasta Summer Cold Water Pool Management:  The extent of incidental take is the spawning habitat that exceeds 53.5°F in Tier 1 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  For Tier 1 years the temperature target will be 53.5°F at CCR, with acceptable exceedances of no more than 5 consecutive days.  Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).  No more than two consecutive years in which winter-run Chinook salmon ETF survival is less than 15%, and where measures must be taken towards achieving ETF survival of at least 15% for the third year, including those measures outlined in the final PA Section 4.10.1.4.2 (Conservation Measures).	Amount or Extent of Winter-Run Chinook Salmon Take

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Upper Sacramento Shasta: Tier 4 (Shasta Summer Cold Water Pool Management)	Sacramento Shasta: Tier 3 (Shasta Summer Cold Water Pool Management.)	Action Component (by division)
Water Temperature under Tier 4 management Eggs/Fry (Keswick Dam - CCR gauge)	Water Temperature under Tier 3 management Eggs/Fry (Keswick Dam - CCR gauge)	Stressor and Life Stage (location)
May - October (May 15 – October 31)	May - October (May 15 – October 31)	Life Stage Timing (Work Window Intersection)
High	High	Magnitude of Effect
High: Supported by multiple scientific and technical publications that include quantitative models specific to the region and species.	High: Supported by multiple scientific and technical publications that include quantitative models specific to the region and species.	Weight of Evidence
Reduced survival probability (79% - 81% temperature dependent mortality).	Reduced survival probability (28% - 34% temperature dependent mortality).	Probable Change in Fitness
Lethal: Temperatures higher than 53.5°F would result in reduced survival probability (increase in mean temperature-dependent mortality of 79 percent [Anderson] and 81 percent [Martin]; the standard deviations are +/- 14 percent [Anderson] and +/- 16 percent [Martin]).	Lethal: Temperatures higher than 53.5°F would result in reduced survival (mean temperature-dependent mortality of 28 percent [Anderson] and 34 percent [Martin]; the standard deviations are +/- 25 percent [Anderson] and +/- 31 percent [Martin]).	Type of Incidental Take
Ecological surrogates related to Shasta Summer Cold Water Pool Management: The extent of incidental take is the spawning habitat that exceeds 53.5°F, in Tier 4 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  For Tier 4 years the temperature target will be determined in real-time with technical assistance from NMFS and USFWS.  Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Ecological surrogates related to Shasta Summer Cold Water Pool Management.:  The extent of incidental take is the spawning habitat that exceeds 53.5°F, in Tier 3 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).  No more than two consecutive years in which winter-run Chinook salmon, ETF survival is less than 15%, and where measures must be taken towards achieving ETF survival of at least 15% for the third year, including those measures outlined in the final PA Section 4.10.1.4.2 (Conservation Measures).	Amount or Extent of Winter-Run Chinook Salmon Take  year, including those measures outlined in the final PA Section 4.10.1.4.2 (Conservation Measures).

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Upper Sacramento Shasta: Spring Pulse Flow	Upper Sacramento Shasta: Fall and Winter Refill and Redd Maintenance	Action Component (by division)
Reduced storage caused by spring pulse releases (May 1 – May 15), reduces Reclamation's ability to provide suitable spawning and	To build storage for the subsequent year class, Fall flows are reduced from the high summer flow. This reduction of flows is likely to influence Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function.  Juveniles (Upper Sacramento River)	Stressor and Life Stage (location)
May – October (NA)	July - December (October, November)	Life Stage Timing (Work Window Intersection)
Medium - High	High	Magnitude of Effect
Medium: High level of understanding of the relationship between temperature and egg/fry survival, but limited understanding of the effects of seasonal operations on storage and temperature.	Medium: Supported by select technical publications specific to the region and species. Quantitative results include month-to-month change.  Low: Substantial uncertainty with WUA analyses for the juvenile rearing life stage.  Quantitative results include WUA analysis.	Weight of Evidence
Decreased survival probability (<2% - 6% egg/fry mortality)	Decreased survival probability,  Decreased growth rate, Reduced survival probability	Probable Change in Fitness
Lethal: Summer temperatures higher than 53.5°F would result in increased egg/fry mortality.	Lethal: Decreased month-to-month flows resulting in stranding caused by a loss of floodplain inundation and side-channel habitat.  Sublethal: Reduced growth and increased competition and predation related to decreased habitat carrying capacity (WUA) at lower flows	Type of Incidental Take
The extent of incidental take is all eggs or fry exposed to water temperatures greater than 53.5°F as a result of implementing a spring pulse. Expected take would include the marginal difference in temperature-dependent mortality caused by lower initial Shasta storage on May 1, which is approximately 2% - 6% of eggs/fry in years with a spring pulse.	<ul> <li>No more than two consecutive years in which winter-run Chinook salmon, ETF survival is less than 15%, and where measures must be taken towards achieving ETF survival of at least 15% for the third year, including those measures outlined in the final PA Section 4.10.1.4.2 (Conservation Measures).</li> <li>The extent of incidental take is all juveniles stranded throughout the upper Sacramento River from the Keswick Dam to RBDD that cannot rear or migrate because of lower flows.</li> <li>July 1 – March 31:         <ul> <li>Releases reduced between sunset and sunrise</li> <li>Keswick releases &gt; 6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour.</li> <li>Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.</li> <li>Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night.</li> <li>Variance allowed for flood control releases.</li> </ul> </li> <li>In situations where Reclamation determines that exceeding these ramping rates would provide a benefit to water storage, a species of concern, or some other benefit, Reclamation may do so with NMFS concurrence.</li> <li>In situations of emergency, Reclamation may exceed these ramping rates, and within two weeks Reclamation will provide to NMFS an assessment of operations and their effects during the emergency reduction in flow. Reclamation may modify the EOS storage levels and associated Keswick flow target with NMFS technical assistance.</li> </ul>	Amount or Extent of Winter-Run Chinook Salmon Take

						Eggs/Fry (Keswick Dam - CCR gauge)	
The extent of take is described by the number of redds exposed to temperatures in excess of 53.5°F between May 1 and May 15, as well as the period between the time of 95% WR alevin emergence and October 31 or 100% emergence.  Expected take prior to summer temperature management would be 1% of winter-run Chinook salmon redds (average proportion of redds constructed prior to May 15).  Expected take after summer temperature management would be no greater than 5% of winter-run Chinook salmon redds.	Lethal: Temperatures higher than 53.5°F would result in reduced survival	Reduced survival	High: Survival- temperature relationship supported by multiple scientific and technical publications that include quantitative models specific to the region and species.	Medium - High	May - October (May 1 - May 15, and 95% WR alevin emergence - October 31)	Water Temperatures. Redds constructed carlier than May 15 would not be protected. Eggs/Fry still in redds after the end date of temperature management (10/31, or when 95% alevin have emerged) would also not protected.	Sacramento Shasta: Shasta Summer Cold Water Pool Management
						incubation Water Temperatures Eggs/Fry (Upper Sacramento River)	
Amount or Extent of Winter-Run Chinook Salmon Take	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)

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Action Component (by division)	Sacramento Shasta: Winter Minimum flows	Delta. DCC Gate operations
Stressor and Life Stage (location)	Flow Conditions Juveniles (Upper mid-Sacramento River)	Altered Hydrodynamics downstream of DCC location Juveniles - Sacramento River - Delta
Life Stage Timing (Work Window Intersection)	July - December (December)	Juvenile migration and rearing - October - April (October - January)
Magnitude of Effect	Low	Low - High
Weight of Evidence	Medium: Supported by select technical publications specific to the region and species. Quantitative results include month-to-month change.  Low: Substantial uncertainty with WUA analyses for the juvenile rearing life stage. Quantitative results include WUA analysis.	High - There are a number of publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modelling results.
Probable Change in Fitness	Decreased survival probability,  Decreased growth rate, Reduced survival probability	Reduced fitness and/or survival when gates are open
Type of Incidental Take	Lethal: Decreased month-to- month flows resulting in stranding caused by a loss of floodplain inundation and side- channel habitat.  Sublethal: Reduced growth and increased competition and predation related to decreased habitat carrying capacity (WUA) at lower flows	Minor to lethal: Increased mortality when gates are open due to changes in routing or transit time through interactions with changes in river flow and tidal influence downstream of DCC location and gate operations
Amount or Extent of Winter-Run Chinook Salmon Take	Ecological surrogates related to Winter Minimum Flows: The extent of incidental take is all juveniles stranded throughout the upper Sacramento River from the Keswick Dam to RBDD because of lower flows.  • July 1 – March 31:  • Releases reduced between sunset and sunrise of Releases reduced between sunset and sunrise releases may not exceed 15% per night, and no more than 2.5% per hour.  • Keswick releases 4,000 cfs, reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.  • Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night.  • Variance allowed for flood control releases. In situations where Reclamation determines that exceeding these ramping rates would provide a benefit to water storage, a species of concern, or some other benefit, Reclamation may do so with NMFS concurrence. In situations of emergency, Reclamation may exceed these ramping rates, and within two weeks Reclamation will provide to NMFS an assessment of operations and their effects during the emergency reduction in flow.  Reclamation may modify the EOS storage levels and associated Keswick flow target with NMFS technical assistance.	Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1) Gates closed Dec-Jan except for up to 2 water quality events in drought conditions of up to 5-days each. Gates open October through November allowing flow into the Delta interior, except if KLCI or SCI trigger is exceeded, then gates closed until triggers are no longer exceeded.

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Action Component (by division)	Delta: DCC Gate operations	Delta: DCC Gate operations	Delta CVP/SWP South Delta Exports	Delta: CVP/SWP South Delta Exports
Stressor and Life Stage (location)	Routing Juveniles - Sacramento River - Delta	Transit times Juveniles - Sacramento River -Delta	Altered hydrodynamics in south Delta/ routing Juveniles - Sacramento River -Delta	Entrainment and loss at the south Delta export facilities
Life Stage Timing (Work Window Intersection)	Juvenile migration and rearing - October – April (October – January)	Juvenile migration and rearing - October – April (October – January)	Juvenile migration and rearing - October - April (October April)	Juvenile migration and rearing - October – April (October April)
Magnitude of Effect	Medium	Medium	Medium	Medium - sustained high frequency exposure on small proportion of population
Weight of Evidence	High - There are a number of publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modelling results.	High - There are a number of publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modelling results.	Medium to High - effects of hydrodynamics well studied and modelled. Effects of hydrodynamics on salmonid migrations in south Delta less certain.	High - Numerous studies have evaluated the efficiency of the screening facilities, predation, as well as survival through the facilities
Probable Change in Fitness	Reduced survival	Reduced survival	Reduced survival, reduced growth	Reduced survival
Type of Incidental Take	Lethal: increased mortality due to routing into the delta interior with lower survival rates	Lethal: Increased mortality due to increased migration times with concurrent increased exposure to predators	Sublethal to lethal: Mortality or decrease in condition due to migratory delays in response to altered hydrodynamics in channels of the south Delta caused by flows more negative than - 5,000 cfs. Loss of appropriate migratory cues. Delays increase transit time and exposure to predators, poor water quality, and contaminants.	Lethal:  Mortality of fish occurs during the salvage process, resulting in the loss of
Amount or Extent of Winter-Run Chinook Salmon Take	Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1) Gates open October through November allowing flow into the Delta interior, except if KLCI or SCI trigger is exceeded, then gates closed until triggers are no longer exceeded. Gates closed Dec-Jan except for opening for up to 2 water quality events in drought conditions of up to 5-days each. Approximately 50 percent of annual brood year winterrun juveniles in Delta by end of January.	Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1)  Gates open October through November allowing flow into the Delta interior, except if KLCI or SCI trigger is exceeded, then gates closed until triggers are no longer exceeded. Up to 25 percent of population of juvenile winter run may enter Delta by early December.  Gates closed Dec-Jan except for opening for up to 2 water quality events in drought conditions of up to 5-days each.	Ecological Surrogates related to OMR management that make OMR flows more negative:  OMR flows can be more negative than -5,000 cfs prior to January 1.  OMR Restrictions from ~January 1 through June 30 (specific dates depend on species-specific OMR onset and offramp).  OMR limited to no more negative than -5,000 cfs except during Storm Flex actions, which may make OMR flows substantially more negative, with some exceptions as described in Section 2.5.5.8.4.4 Storm related OMR flexibility.	Annual incidental take limit of highest historical loss for wild wniter-run Chinook for the period between 2010 and 2018 indexed to the winter-run JPE plus 20 percent (1.6 percent of annual JPE).  Annual incidental take for hatchery winter-run Chinook salmon is 0.8 percent of hatchery JPE.

Ecological surrogate related to water diversion rate at Barker Slough Pumping Plant: (See Section 2.11.1.6.2) Diversion up to 175 cfs	Minor: Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Minimal decrease in fitness	High - monitoring has few observations of Chinook salmon at this location, multiple studies regarding efficiency of positive barrier fish screens	Low - screens are designed for delta smelt criteria, few salmonids expected to be present at screen location	Juvenile migration and rearing - October – April (October – April)	Entrainment and impingement onto fish screens  Juveniles - Sacramento River -Delta	Delta North Bay Aqueduct
Ecological surrogate related to water diversion rate at Barker Slough Pumping Plant: (See Section 2.11.1.6.2) Diversion up to 175 cfs	Minor: Increased mortality due to routing into the channels of the Lindsey Slough/ Barker Slough region	Reduced fitness	Medium - few Chinook salmon observed in regional monitoring efforts in the past. No fish observed behind screens in monitoring efforts.	Low - very small proportion of population will be present in Barker Slough, low impacts of diversion volumes on hydrodynamics	Juvenile migration and rearing - October – April (October – April)	Routing Juveniles - Sacramento River -Delta	Delta North Bay Aqueduct
See SWP/CVP Salvage operations discussion	Lethal: Increased mortality of entrained fish at the CVP and SWP fish salvage facilities	Reduced survival	High - numerous studies have evaluated the potential risk to salmonids entering the Delta interior and becoming vulnerable to entrainment at the fish salvage facilities.	Low - sustained population effects on a small to medium proportion of the population present in the Delta	Juvenile migration and rearing - October – April (October – January)	Increased entrainment and loss at the South Delta Exports facilities  Juveniles - Sacramento River -Delta	Delta: DCC Gate operations
Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1) Gates open October through November allowing flow into the Delta interior, except if KLCl or SCl trigger is exceeded, then closed gates are closed until triggers are no longer exceeded.  Gates closed Dec-Jan except gates opening for up to 2 water quality events in drought conditions of up to 5-days each.  May 21 – June 15 14 days of closed gates; remainder of days gates are open.	Minor: Increased straying into the Mokelumne River system when gates are opened for water quality concerns, followed by migratory delays when gates are closed	Delayed migration, possible reduction of spawning success	Medium - tagging studies related to straying of Chinook through the DCC when open.	Low	November – June (November – January; May 21 - June 15)	Routing Adults - Sacramento River - Delta	Delta: DCC Gate operations
	fish entrained into the facilities					Juveniles - Sacramento River -Delta	
Amount or Extent of Winter-Run Chinook Salmon Take	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)

Ecological surrogate related to water diversion rate at Rock Slough Pumping Plant: (See Section 2.11.1.6.4)  Diversion up to 350 cfs	Minor to lethal: Delayed migration and increased transit times with potential for increased mortality due to routing into the channel of Rock Slough where predation is likely to be elevated	Reduced fitness due to delay in migration or increased predation.	Medium - annual monitoring reports indicate that no fish are entrained through the screens, however some fish are observed in front of the screens, and have been observed in historical monitoring.	Low - small numbers of fish are likely to be in the vicinity of the fish screens and intake	Juvenile migration and rearing - October – April (October – April)	Kouting  Juveniles - Sacramento River -Delta	Rock Slough water diversions
Up to 5 listed juvenile salmonids (which may include winter-run Chinook salmon) per year – take is likely to be lethal.	Minor to lethal: Injury or death due to impingement, capture by grappling hooks during weed removal	Minimal decrease in fitness	Low - No reports or studies available	Low - fish unlikely to be in area of screens during cleaning	Juvenile migration and rearing - October – April (October – April)	Impingement/ capture during aquatic weed cleaning  Juveniles - Sacramento River -Delta	Delta North Bay Aqueduct
Up to 5 listed juvenile salmonids (which may include winter-run Chinook salmon) per year – take is likely to be lethal.	Minor to lethal: Injury or death due to entrainment into dredge or impingement onto fish screens	Minimal decrease in fitness	Low - No reports or studies available	Low - fish unlikely to be in area of screens during cleaning	Juvenile migration and rearing - October - April (October - April)	Entrainment during sediment cleaning  Juveniles - Sacramento River -Delta	Delta: North Bay Aqueduct
Amount or Extent of Winter-Run Chinook Salmon Take	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)

Action Component (by division)	Delta Predator removal studies		Delta CVP Improvements	Delta Suisun Marsh/ Roaring River Food Distribution Studies
Stressor and Life Stage (location)	Capture in sampling gear Adults and Juveniles - Sacramento River - Delta(Clifton	River – Delta(Clifton Court Forebay)	CO2 Injections Juveniles - Sacramento River -Delta	Habitat management Juveniles - Sacramento River -Delta
Life Stage Timing (Work Window Intersection)	Juvenile migration and rearing - October – April (January-April)		Juvenile migration and rearing - Oct – April (October – April)	Juvenile migration and rearing - Oct – April (October – April)
Magnitude of Effect	Low - infrequent sampling. Study occurs over two to three years of PA duration		Low	Low
Weight of Evidence	Medium - Several reports from previous predator removal studies, literature on sampling methods.		Medium – several studies show effectiveness of CO2 in removal of predators and sensitivity of smaller fish to CO2 exposure	Medium – several studies have assessed migratory delays at the Suisun Marsh radial gates,
Probable Change in Fitness	Reduced survival		Reduced fitness	Minor reductions to fitness caused by delays
Type of Incidental Take	Sublethal to lethal: Increased vulnerability to injury and predation due to entanglement/entrapm ent in sampling gear	3	Sublethal to lethal: Small increase in morbidity and mortality due to CO2 exposure during predator clean outs of secondary channel	Minor: Management of flows entering Suisun Marsh and Roaring River to improve food supplies for Delta smelt, potential temporary migratory delays and blockages.
Amount or Extent of Winter-Run Chinook Salmon Take	Over the two-year study Predator Reduction Electrofishing Study:  • Incidental take of up to 50 adult or juvenile winterrun Chinook salmon cumulative, with no more than 3 mortalities.  Over the two-year Predator Fish Relocation Study:  • Incidental take of up to 50 adult or juvenile winter-	Over the two-year Predator Fish Relocation Study:  • Incidental take of up to 50 adult or juvenile winterrun Chinook salmon cumulative, with no more than 3 mortalities.	Operations of CO2 injector covered under SWP/CVP operations for salvage and loss (see "CVP/SWP South Delta Exports") as it will be part of standard operations in the future.	Ecological surrogate based on the SMSCG operations: (See Section 2.11.1.6.6)  • June – September – no more than 60 days of gate closure.  • Oct-May – no more than 20 days of gate closure.  • Boat locks are kept open except as needed for boat transit.  • Gate closures only on flood tides

		related effects					
Seasonal Operations and other Core Water Operations)		reductions) to Reduced Reduced Reduced survival due water					
Take is exempted to the extent that it is covered under the effects of action components described above (export operations, Salinity Control Gate Operations,	Sublethal to lethal	Variable – Benefits to survival	Low	Variable – Beneficial to Medium	Fall-Summer	Egg incubation, juvenile rearing	Delta Smelt Habitat Action
Implementation of required ramping rates for reduction of releases from Keswick Reservoir to minimize stranding.	releases.			substantially,	(July – November)		
Maximum volumes of transferred water restricted to permitted amounts.	pools following reduction of reservoir	stranding as flows recede	Sacramento River.	to change river elevations	Sacramento River  – July –December		
Transfers allowed only during the July through November transfer window.	Isolation and stranding in side channels and	survival due to	conducted on Chinook salmon stranding in upper	river flow related to transfers not expected	holding, and migration upper	following end of transfer releases	Transfers
Ecological surrogates related to water transfers	Subjethal to lethal	Reduced	Medium - several studies	I ow _changes in	Invenile regrino	Stranding	Delta Water
Sept 15 notch in barrier weirs or flashboard removal Sept 15.No barrier operations between December 1 and April 30.			Delta channels is well documented by salvage records.	minimal.			
At least 1 tidal flap tied open if water temperature < 22°C.	due to increased exposure to predators		predation risks. Timing of winter-run in the south	the barriers is expected to be		The strength of the strength o	
Installation of barriers no earlier than May 1.  May 16 to May 31 tidal flags on culverts field open	increased mortality		Delta and increase	period, exposure to	(early May late emigrating fish)	Sacramento River -Delta	Barriers
	increased transit times		barriers increase transit	very tail end of	October - April	Juveniles -	Agricultural
Ecological surrogates related to barrier operations: (See Section 2.11.6.8)	Sublethal to lethal: Delayed migration and	Reduced survival	Medium - several studies have indicated that the	Low - installation of barriers occurs at the	Juvenile migration and rearing -	Transit times	Delta: South Delta
Amount or Extent of Winter-Run Chinook Salmon Take	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)

### 2.11.1.2 CV Spring-run Chinook Salmon Incidental Take Table

Table 2.11.1-2. CV Spring-run Chinook Salmon Incidental Take

Management)  Basalt and Porous Lava Diversity Group	Minimum instream base flows  Northwestern California Diversity Group Upper Sacramento Shasta Summer Cold Water Pool	Clear Creek: Spring attraction/channe I maintenance	Clear Creek: Minimum instream base flows Northwestern California Diversity Group		Action Component (by division)
(47) 45	P Water Temperature  r Eggs/Fry of (Keswick Dam -	ride Flow Conditions  Flow Conditions  ne Juveniles/smolts: creek-wide	20		Stressor and Life Stage (location)
March - October (May 15 – October 31)	August - December (August - October 31)	Year round	Year round		Life Stage Timing (Work Window Intersection)
Low	High	Medium	Low		Magnitude of Effect
Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	High: Supported by multiple scientific and technical publications	Medium: current data on species occurrence, and supported by technical publications on flow	Low		Weight of Evidence
Reduced reproductive success	Reduced survival	Reduced survival	Reduced growth, survival, and life history diversity		Probable Change in Fitness
Sublethal: Temperatures in excess of 61°F TDADM expected to lead to stress, disease, and bioenergetic depletion.	magnitude of effect. magnitude of effect.  Lethal:  Temperatures higher than 53.5°F would cause a decrease in egg	Sublethal: Flow decreases cause isolation and stranding, Ramping rates will reduce the	Minor: Static flow regime restricts access to rearing habitat and refugia, and does not provide migratory cues.	redds and cause egg/alevin mortality.	Type of Incidental Take
Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  For Tier 1 years the temperature target will be 53.5°F at CCR, with acceptable exceedances of no more than 5 consecutive days.  Shasta operations will remain consistent with performance metrics described in the final PA	majority of the creek (Section 2.5.3.4.2 Clear Creek Flow Releases).  The extent of incidental take is rearing habitat exposed to reductions in flow during controlled flow decrease from Whiskeytown Reservoir.  Ecological surrogates related to Shasta Summer Cold Water Pool Management:  The extent of incidental take is the spawning habitat that exceeds \$3.5°F or 61°F (7DADM) in Tier 1 years, according to the following criteria:	The ecological surrogate is the proposed flow ramping rates.  • Flow decreases up to 25 cfs per hour, and timed such that the maximum rate of flow decrease occurs primarily during dark hours through the	The ecological surrogate is flow within juvenile rearing habitat.  The extent of incidental take is all juveniles exposed tothe minimum base flows described in the proposed action, in years without channel maintenance flows (40%).		Amount or Extent of CV Spring-run Chinook Salmon Take

Ecological surrogates related to Shasta Summer Cold Water Pool Management:	Lethal: Temperatures higher than 53.5°F would			High		Water Temperature	Upper Sacramento /Shasta: Tier 4 (Shasta Summer
Ecological surrogates related to Shasta Summer Cold Water Pool Management: The extent of incidental take is the spawning habitat that exceeds 53.5°F or 61°F (7DADM), in Tier 3 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Lethal: Temperatures higher than 53.5°F would cause a decrease in egg survival. Sublethal: Temperatures in excess of 61°F 7DADM expected to lead to stress, disease, and bioenergetic depletion.	Reduced survival probability Reduced reproductive success	High: Supported by multiple scientific and technical publications  Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	High Low	August - December (August - October 31)  March - October (May 15 - October 31)	Water Temperature Eggs/Fry (Keswick Dam - BSF gauge) Holding & Spawning Adults (Keswick Dam - BSF gauge) BSF gauge)	Upper Sacramento Shasta: Tier 3 Shasta Summer Cold Water Pool Management) Basalt and Porous Lava Diversity Group
Ecological surrogates related to Shasta Summer Cold Water Pool Management:  The extent of incidental take is the spawning habitat that exceeds 53.5°F or 61°F (7DADM) in Tier 2 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  Shasta operations will remain consistent with performance metrics described in the Final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Lethal: Temperatures higher than 53.5°F would cause a decrease in egg survival. Sublethal: Temperatures in excess of 61°F 7DADM expected to lead to stress, disease, and bioenergetic depletion.	Reduced survival probability  Reduced reproductive success	High: Supported by multiple scientific and technical publications  Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	High Low	August - December (August - October 31)  March - October (May 15 - October 31)	Water Temperature Eggs/Fry (Keswick Dam - BSF gauge) Holding & Spawning Adults (Keswick Dam - BSF gauge)	Upper Sacramento Shasta: Tier 2 (Shasta Summer Cold Water Pool Management) Basalt and Porous Lava Diversity Group
Amount or Extent of CV Spring-run Chinook Salmon Take Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)

Action Component (by division)	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CV Spring-run Chinook Salmon Take
Cold Water Pool Management)	Eggs/Fry (Keswick Dam - BSF gauge)	August - December (August - October 31)	Low	High: Supported by multiple scientific and technical publications	Reduced survival probability	cause a decrease in egg survival. Sublethal:	The extent of incidental take is the spawning habitat that exceeds 53.5°F or 61°F (7DADM), in Tier 4 years, according to the following criteria:
Basalt and Porous Lava Diversity Group	Holding & Spawning Adults (Keswick Dam -	March - October (May 15 – October		Medium: Supported by multiple scientific and technical publications, however not specific to	Reduced reproductive success	Temperatures in excess of 61°F 7DADM expected to lead to stress, disease, and bioenergetic	<ul> <li>Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.</li> </ul>
	BSF gauge)	31)		however not specific to the region and species.		and bioenergetic depletion.	<ul> <li>For Tier 4 years the temperature target will be determined in real-time with technical assistance from NMFS and USFWS.</li> </ul>
						7	<ul> <li>Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).</li> </ul>
Upper Sacramento /Shasta Fall and Winter Refill and Redd Maintenance	Spawning Habitat Availability, Flow Conditions, Loss of Riparian	August - December (October, November)	High	Medium: Supported by a limited number of scientific and technical publications specific to the region and species.	Reduced survival probability	Lethal: Decreased month-to- month flows resulting in possible redd dewatering and decreased floodplain	Ecological surrogates related to Fall and Winter Refill and Redd Maintenance: The extent of incidental take is all spring-run redds dewatered throughout the upper Sacramento River from the Keswick Dam to RBDD because of lower flows.
Basalt and Porous Lava Diversity Group	Instream Cover, Loss of Natural River Morphology and Function			month-to-month channel inundation (USFWS 2006).		inundation and side- channel habitat.	Incidental take of spring-run redds is expected proportional to the dewatering of fall-run redds which are cotemporaneous and more abundant. Dewatering would also occur proportional to the flow reduction such that expected take will be no greater than:
	Redds (Upper Sacramento						<ul> <li>41% of redds at 3,250 cfs.</li> <li>29% of redds at 4,000 cfs,</li> </ul>
	River)						<ul> <li>22% of redds at 4,500 cfs,</li> <li>15% of redds at 5,000 cfs</li> </ul>
Upper Sacramento	Flow Conditions, Loss of Riparian	November - April (December -	High	High: Supported by multiple scientific and	Decreased growth rate,	Sublethal to lethal: Decreased habitat	The extent of incidental take is all juveniles stranded or delayed throughout the upper Sacramento River from
Minimum flows	Habitat and Instream Cover,	rebruary)		specific to the region and	Decreased	carrying capacity (WUA) at lower flows	because of lower flows.
Basalt and	Loss of Natural			species. Quantitative	probability	providing decreased	<ul> <li>July 1 – March 31:</li> </ul>
Porous Lava	Morphology and			analysis and month-to-		and increased	o Releases reduced between sunset and sunrise
Diversity Group	Function			month floodplain inundation.		competition and predation. Decreased	<ul> <li>Keswick releases &gt; 6,000 cfs, reductions in releases may not exceed 15% per night, and no</li> </ul>
	Juveniles (Upper					month-to-month flows	more than 2.5% per hour.
	River)					floodplain inundation	

CVP/SWP Altered  Delta hydrodynamics s in south Delta/ tions from routing  restern routing  restern Juveniles - tty Group, Sacramento and River - Delta	Delia:     DCC Gate     Altered     Juvenile migratio       operations     Hydrodynamics     and rearing -       Populations from     downstream of     December - May       Northwestern     DCC location     (December -       California     Diversity Group,     Juveniles -     January; May 21       Basalt and     Sacramento       Porous Lava     River -Delta       Diversity Group,     River -Delta       Northern Sierra     River -Delta       Nevada Diversity     River -Delta		Action Stressor and Life Component (by Life Stage Win division) (location) Inters
Juvenile migration Medium to High and rearing - December – May (December – May)	Juvenile migration High and rearing - December – May (December – January; May 21 – May 31)		Life Stage Magnitude of Effect Timing (Work Window Intersection)
Medium to High - effects of hydrodynamics well studied and modelled. reffects of hydrodynamics on salmonid migrations in south Delta less certain.	High - There are a number of publications regarding the relative survival in various North Delta and Central Delta migratory routes; conclusions supported by modelling results.		Weight of Evidence
Reduced survival, reduced growth	Reduced fitness and/or survival when gates are open		Probable Change in Fitness
Sublethal to lethal: Mortality or decreases in condition due to migratory delays in response to altered hydrodynamics in channels of the south Delta. Loss of appropriate migratory cues. Delays increase transit time and	Minor to lethal: Increased mortality when gates are open due to changes in routing or transit time through interactions with changes in river flow and tidal influence downstream of DCC location and gate operations	and side-channel habitat.	Type of Incidental Take
Ecological surrogates related to OMR management that make OMR flows more positive: OMR flows can be more negative than -5,000 cfs prior to January 1.  OMR Restrictions from ~January 1 through June 30 (specific dates depend on species-specific OMR onset and offramp).  OMR limited to no more negative than -5,000 cfs except during Storm Flex actions, which may make OMR flows substantially more negative, with some exceptions.	Ecological surrogates related to barrier operations (see Section 2.11.1.6.1) Gates closed Dec-Jan except for opening for up to 2 water quality events in drought conditions of up to 5-days each. May 21 – June 15 14 days of closed gates; remainder of days gates are open.	O Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.  O Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night.  O Variance allowed for flood control releases.  In situations where Reclamation determines that exceeding these ramping rates would provide a benefit to water storage, a species of concern, or some other benefit, Reclamation may do so with NMFS concurrence.  In situations of emergency, Reclamation may exceed these ramping rates, and within two weeks Reclamation will provide to NMFS an assessment of operations and their effects during the emergency reduction in flow.	Amount or Extent of CV Spring-run Chinook Salmon Take

Gates closed Dec-Jan except for opening for up to 2 water quality events in drought conditions of up to 5-days each.	delta interior with lower survival rates when gates are open.		survival in various North Delta and Central Delta migratory routes;		(December – January, May 21 – June15)	Sacramento River - Delta	Northwestern California Diversity Group, Basalt and
Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1)	Lethal: Increased mortality due to routing into the	Reduced survival	High - There are a number of publications regarding the relative	Medium to High	Juvenile migration and rearing - December - May	Routing  Juveniles -	operations Populations from
Ecological surrogates related to barrier operations: (See Section 2.11.1.6.8)  Installation of barriers no earlier than May 1. May 16 to May 31, tidal flaps on culverts tied open. At least 1 tidal flap tied open if water temperature < 22°C. Sept 15 notch in barrier weirs or flashboard removal Sept 15 No barrier operations between December 1 and April 30.	Sublethal to lethal: Delayed migration and increased transit times with potential for increased mortality due to increased exposure to predators	Reduced survival	Medium - several studies have indicated that the barriers increase transit time through the south Delta and increase predation risks. Timing of spring-run in the south Delta channels is well documented by salvage records.	Medium to High - installation of barriers occurs during SR migratory period, exposure to the barriers is expected to be low for Sacramento River basin SR, high for SJR basin population SR, and phenotypic spring-run from the Stanislaus River.	Juvenile migration and rearing - December – May (May – early June)	Transit times Juveniles - Sacramento River -Delta	Delta South Delta Agricultural Barriers Populations from Northwestern California Diversity Group, Basalt and Porous Lava Diversity Group, Northern Sierra Nevada Diversity Group and Southern Sierra Nevada Diversity Group
OMR flow is restricted to no more negative than -5,000 cfs to protect YOY spring-run Chinook salmon when more than 5 percent of the YOY spring-run population is in the Delta except during Storm Flex operations when OMR flows may be more negative than -5,000 cfs.  Take limit of 1 percent loss of each surrogate yearling spring-run releases group (CNFH late-fall run Chinook salmon)	Lethal: Mortality of fish occurs during the salvage process, resulting in the loss of fish entrained into the facilities	Reduced survival	High - Numerous studies have evaluated the efficiency of the screening facilities, predation, as well as survival through the facilities	Medium to High - sustained high frequency exposure on small proportion of population	Juvenile migration and rearing - December – May (December – May)	Entrainment and loss at the south Delta export facilities  Juveniles - Delta	Delta: CVP/SWP South Delta Exports Populations from Northwestern California Diversity Group, Basalt and Porous Lava Diversity Group, Northern Sierra Nevada Diversity Group and Southern Sierra Nevada Diversity Group
Amount or Extent of CV Spring-run Chinook Salmon Take	Type of Incidental Take poor water quality, and contaminants.	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)  Southern Sierra Nevada Diversity Group

Action Component (by	Stressor and Life Stage	Life Stage Timing (Work	Magnitude of Effect	Weight of Evidence	Probable Change in	Type of Incidental	Amount or Extent of CV Spring-run Chinook Salmon Take
division)	(location)	Window Intersection)			Fitness	(December)	
Porous Lava Diversity Group,				conclusions supported by modelling results.			May 21 – June 15 14 days of closed gates; remainder of days gates are open.
Northern Sierra Nevada Diversity Group							
Delta: DCC Gate operations	Transit times	Juvenile migration and rearing -	Medium to High	High - There are a number of publications	Reduced survival	Lethal: Increased mortality	Ecological surrogates related to DCC gate Operations: (See Section 2.11.1.6.1)
Populations from Northwestern	Juveniles - Sacramento	December – May (December –		regarding the relative survival in various North		due to increased migration times with	Gates closed Dec-Jan except for opening for up to 2 water quality events in drought conditions of up to 5-
California Diversity Group	River -Delta	January, May 21 – June 15)		Delta and Central Delta		concurrent increased	days each.  May 21 – June 15 14 days of closed pates: remainder
Basalt and Porous Lava		omero)		conclusions supported by modelling results.		within the Delta interior. Access to	of days gates are open.
Diversity Group, Northern Sierra Nevada Diversity						Delta interior when the gates are open.	
Delta: South	Transit times	Adult migration -	Medium - installation	Medium - several studies	Reduced	Sublethal to lethal:	Ecological surrogates related to barrier operations: (See
Agricultural	Adults - Delta	January – June (May – June)	during adult SR	barriers increase transit	Survival	increased transit times	Section 2.11.1.0.a)
Populations from			exposure to the	Delta and increase		increased mortality	Installation of barriers no earlier than May 1.
Nevada Diversity			to be high for SJR	predation risks. 1 iming of spring-run in the south Delta channels is well		exposure to warmer water conditions while	May 16 to May31, tidal flaps on culverts tied open.
-			and phenotypic	documented by salvage records.		moving upriver over	At least 1 tidal flap tied open if water temperature < 22°C.
			Stanislaus River.				Sept 15 notch in barrier weirs or flashboard removal Sept 15
							Barriers are removed by November 30 of each year
Delta: DCC Gate operations	Routing	January – June (January, May 21-	Low	Medium - tagging studies related to straying of	Delayed migration,	Minor: Increased straying into	Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1)
Northwestern	Sacramento	,		DCC when open.	reduction of	system when gates are	Gates closed Dec-Jan except for opening for up to 2
Diversity Group,	Kiver - Della				spawning	migratory delays when	water quality events in drought conditions of up to 5-days each.
Basalt and Porous Lava						gates are closed for water quality concerns	May 21 – June 15 14 days of closed gates; remainder of days gates are onen
Diversity Group, Northern Sierra						3	Gates open after June 16
Nevada Diversity							

Antion	Ctracear and	I ifa Staga	Magnitude of Effect	Waight of Evidones	Drohahlo	Tuna of Incidental	A mannet ar Evenet of CV Saring-run Chinoak
Component (by division)	Life Stage (location)	Timing (Work Window Intersection)	g	O.	Change in Fitness	Take	Salmon Take
Delta: DCC Gate operations From Northwestern California Diversity Group, Basalt and Porous Lava Diversity Group, Northern Sterra Nevada Diversity Group	Increased entrainment and loss at the South Delta Exports facilities Juveniles - Sacramento River -Delta	Juvenile migration and rearing - December – May (December – May)	Low - sustained population effects on a small to medium proportion of the population present in the Delta	High - numerous studies have evaluated the potential risk to salmonids entering the Delta interior and becoming vulnerable to entrainment at the fish salvage facilities.	Reduced survival	Sublethal to lethal: Increased mortality of entrained fish at the CVP and SWP fish salvage facilities	See SWP/CVP Salvage operations
Delta North Bay Aqueduct Populations from Northwestern California Diversity Group, Basalt and Porous Lava Diversity Group, Northern Sierra Nevada Diversity Group North Bay	Routing Juveniles - Sacramento River -Delta	Juvenile migration and rearing - December – May (December – May)	Low - very small proportion of population will be present in Barker Slough, low impacts of diversion volumes on hydrodynamics	Medium - few Chinook salmon observed in regional monitoring efforts in the past. No fish observed behind screens in monitoring efforts.	Reduced survival	Minor: Increased mortality due to routing into the channels of the Lindsey Slough/ Barker Slough region	Ecological surrogate related to water diversion rate at Barker Slough Pumping Plant: (See Section 2.11.1.6.2) Diversion up to 175 cfs  Ecological surrogate related to water diversion rate at
Delta: North Bay Aqueduct Populations from Northwestern California Diversity Group, Basalt and Porous Lava Diversity Group, Northern Sierra Nevada Diversity	Entrainment and impingement onto fish screens Juveniles - Sacramento River -Delta	Juvenile migration and rearing - December – May (December – May)	Low - screens are designed for delta smelt criteria, few salmonids expected to be present at screen location	High - monitoring has few observations of Chinook salmon at this location, multiple studies regarding efficiency of positive barrier fish screens	Minimal change in fitness	Minor: Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Ecological surrogate related to water diversion rate at Barker Slough Pumping Plant: (See Section 2.11.1.6.2) Diversion up to 175 cfs

Intersection)	_	_			_
Delta:         North Bay         Entrainment         Juvenile migration         Low - fish unlik           Aqueduct         during sediment         and rearing -         be in area of scr           Populations from Populations from Northwestern         cleaning (December - May)         during cleaning	ely to eens	Low - No reports or No retudies available f	Minimal change in fitness	Sublethal to lethal: Injury or death due to entrainment into dredge or impingement	Up to 5 listed juvenile salmonids (which includes CV spring-run Chinook salmon) per year – take is likely to be lethal.
up, Sacramento River-Delta up, ra ra sity				onto fish screens	
North Bay Impingement/ Juvenile migration learning and rearing - tions from aquatic weed cleaning cleaning (December – May)	cely to eens	Low - No reports or x tudies available f	Minimal change in fitness	Sublethal to lethal: Injury or death due to impingement, capture by grannling books	Up to 5 listed juvenile salmonids (which includes CV spring-run Chinook salmon) per year – take is likely to be lethal.
up, Juveniles - Sacramento Sacramento River - Delta up, ra ra sity				during weed removal	
CCWD Routing Juvenile migration and rearing - lough Juveniles - December - May December - May (December - May)  riversory River - Delta  mia try Group, and Lava fry Group, and Lava and and Diversity and Diversity  and misigra and misi	ß	Medium - annual from monitoring reports indicate that no fish are entrained through the screens, however some fish are observed in front of the screens, and have been observed in historical monitoring.	Reduced fitness due to delay in migration or increased predation.	Sublethal to lethal: Delayed migration and increased transit times with potential for increased mortality due to routing into the channel of Rock Slough where predation is likely to be elevated	Ecological surrogate related to water diversion rate at Rock Slough Pumping Plant: (See Section 2.11.1.6.4) Diversion up to 350 cfs.

	movements by closed					grounds or as	Diversity Group,
	their downstream					way to spawning	Porous Lava
	may be delayed on					the area on their	Basalt and
	several days. Juveniles					migrate through	Diversity Group,
Gate closures only on Hood rides	from a few hours to					iuveniles mav	California
transit.	delayed in their		operations				Populations from
Boat locks are kept open except as needed for boat	spring-run may be		the Salinity gate		(December – June)	days June-Sept)	Subsidy Studies
Oct-May – no more than 20 days of gate closure.	individual adult		based on a few studies of		December - May	Oct-May, 60	System Food
closure.	operation Oct - May,		Suisun Marsh is medium,		and rearing -	quality (20 days	Distribution
June -September -no more than 60 days of gate	days of periodic		migration and rearing in		Juvenile migration	flow/water	River
(See Section 2.11.1.6.6)	During the annual 20		Chinook salmon		(January – June),	change in water	Marsh Roaring
Ecological surrogate based on the SMSCG operations:	Minor:	Minimal	Medium- data on	Low	Adult migration	Temporary	Delta: Suisun
							Southern Sierra Nevada Diversity Group
							Group and
							Nevada Diversity
							Northern Sierra
							Porous Lava
	secondary channel						Basalt and
	predator clean outs of		exposure				Diversity Group,
	exposure during		of smaller fish to CO2			River -Delta	California
	mortality due to CO2		predators and sensitivity		(December - May)	Sacramento	Northwestern
operations for surrage and ross.	morbidity and	Timeso	CO2 in removal of		December - May	Juveniles -	Populations from
Operations of CO2 injector covered under SWP/CVP	Small increase in	Reduced	Medium – several studies	Low	Juvenile migration	CO2 Injections	Delta, CVP
							Group
							Nevada Diversity
							Southern Sierra
THE PARTY OF THE P							Group and
more than 5 mortalities.							Nevada Diversity
spring-run Chinook salmon cumulative, with no							Northern Sierra
T. 13-11-16-16-16-16-16-16-16-16-16-16-16-16-							Porous Lava
Over the two-year Predator Fish Relocation Study:							Basalt and
more than 5 mortalities.	ent in sampling gear					-53	Diversity Group,
spring-run Chinook salmon cumulative, with no	entanglement/entrapm					juveniles- Delta	California
Incidental take of up to 50 juvenile or adult CV	due to		on sampling methods.	20	33	Adults and	Northwestern
	to injury and mortality		removal studies, literature	three years of study	(January – June)	0	Populations from
Study:	Increased vulnerability	survival	from previous predator	sampling over two to	January – June	sampling gear	removal studies
Over the two-year Predator Reduction Electrofishing	Sublethal to lethal:	Reduced	Medium - Several reports	Low - infrequent	Adult migration -	capture in	Delta: Predator
					Intersection)		200
Salmon Take	Take	Change in Fitness			Timing (Work Window	(location)	division)
Amount or Extent of CV Spring-run Chinook	Type of Incidental	Probable	Weight of Evidence	Magnitude of Effect	Life Stage	Stressor and	Action

Northern Sierra Nevada Diversity Group and Southern Sierra Nevada Diversity Group Group  Delta Water Transfers Populations from Northwestern California Diversity Group, Basalt and Porous Lava Diversity Group, Basalt and Porous Java Diversity Group, Basalt and Porous Java Diversity Group, Basalt Action  Delta Smelt Habitat Action	outmigrating juveniles.  Stranding following end of transfer releases transfer releases juvenile rearing juvenile rearing	Juvenile rearing, holding, and migration upper Sacramento River – November – April (November)  Fall-Summer	Low -changes in river flow related to transfers not expected to change river elevations substantially,  Variable - Beneficial to Medium	Medium – several studies conducted on Chimook salmon stranding in upper Sacramento River.	Fitness  Fitness  Fitness  Reduced survival due to risk of stranding as flows recede  Variable – Benefits to survival (export reductions) to	gates for several hours while gates are closed on flood tides.  Sublethal to lethal Isolation and stranding in side channels and pools following reduction of reservoir releases.  Sublethal to lethal	Ecological surrogates related to water transfers: (See Section 2.11.1.6.5)  Transfers allowed only July through November Maximum volumes of water transfers restricted to permitted amounts (See Section 2.11.1.6.5)  Implementation of ramping rates for reduction of releases from Keswick Reservoir to minimize stranding. (See Section 2.5.6 and Upper Sacramento/ Shasta Water Minimum Flows)  Take is exempted to the extent that it is covered under the effects of action components described above (export operations, Salinity Control Gate Operations, Seasonal Operations and other Core Water Operations)
Dela Water Transfers Populations from Northwestern California Diversity Group, Basalt and Porous Lava Diversity Group, Northern Sierra Nevada Diversity Group	(20)	Juvenile rearing, holding, and migration upper Sacramento River - November - April (November)	Low -changes in river flow related to transfers not expected to change river elevations substantially,	Medium – several studies conducted on Chinook salmon stranding in upper Sacramento River.	Reduced survival due to risk of stranding as flows recede	Sublethal to lethal Isolation and stranding in side channels and pools following reduction of reservoir releases.	Ecological surrogates related to water transfers: (See Section 2.11.1.6.5)  Transfers allowed only July through November Maximum volumes of water transfers restricted to permitted amounts (See Section 2.11.1.6.5)  Implementation of ramping rates for reduction of releases from Keswick Reservoir to minimize stranding. (See Section 2.5.5.6 and Upper Sacramento/ Shasta Water Minimum Flows)
Delta Smelt Habitat Action	Egg incubation, juvenile rearing	Fall-Summer	Variable – Beneficial to Medium	Low	Variable – Benefits to survival (export reductions) to Reduced Reduced Reduced survival due water temperature- related effects	Sublethal to lethal	Take is exempted to the extent that it is covered under the effects of action components described above (export operations, Salinity Control Gate Operations, Seasonal Operations and other Core Water Operations)

#### 2.11.1.3 CCV Steelhead Incidental Take Table

#### Table 2.11.1-3. CCV Steelhead Incidental Take

Sacramento Shasta: Win Minimum flo Basalt and Porous Lava Diversity Gr	Sacramento Shasta: Fall Winter Refill Redd Maintenance Basalt and Porous Lava Diversity Gro	A Comp div
Upper Sacramento Shasta: Winter Minimum flows Masalt and Porous Lava Diversity Group	Upper Sacramento Shasta. Fall and Winter Refill and Redd Maintenance Basalt and Porous Lava Diversity Group	Action Component (by division) Diversity Group
Spawning Habitat Availability, Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function Redds, (Upper mid-Sacramento River)	Spawning Habitat Availability, Flow Conditions, Loss of Riparian Habitat and Instream Cover, Loss of Natural River Morphology and Function Migrating, Spawning Adults (Upper Sacramento River)	Stressor and Life Stage (location)
January - June (January - February)	August - December (October, November)	Life Stage Timing (Work Window Intersection)
High	High	Magnitude of Effect
		of Effect
Medium: Supported limited number of scientific and technic publications specific the region and specific Quantitative results month-to-month chainundation (USFWS 2006).	Medium: Supported select technical publications specific the region and specific Quantitative results include average spa flows to proposed minimum flows.	Weight
Medium: Supported by a limited number of scientific and technical publications specific to the region and species. Quantitative results month-to-month channel inundation (USFWS 2006).	Medium: Supported by select technical publications specific to the region and species. Quantitative results include average spawning flows to proposed minimum flows.	Weight of Evidence
7027 UTT	72-48.7	3057
Reduced survival probability	Reduced survival probability	Probable Change in Fitness
Lethal: Decreased month month flows resul in decreased floos inundation and a temporary loss of spawning habitat leading to steelher redds being dewatered	Lethal: Decreased month month flows resu in possible dewat and stranding as decreased floodp inundation and si channel habitat isolated by reduc flows.	Type o
Lethal: Decreased month to month flows resulting in decreased floodplain inundation and a temporary loss of spawning habitat leading to steelhead redds being dewatered	Lethal: Decreased month to month flows resulting in possible dewatering and stranding as decreased floodplain inundation and side- channel habitat isolated by reduced flows.	Type of Incidental Take
The exten throughou Keswick  July 1-  Rele  Keswick  Keswick  Keswick  Keswick  Kese  Rele  Kese  Rele  Kese  Rele  Kese  Rele  Kese  Redu  Per I  Kes  Cfs;  Cfs;  Cfs I	The extent of incidelayed throughou the Keswick Dam spawn because of  July 1 – March Releases rad Keswick rele Keswick rele Keswick rele releases may more than 2. Keswick rele reductions in reductions in per night, or Keswick rele cfs; reduction fs per night, or Keswick rele cfs; reduction in per night, or Keswick rele cfs; reduction in situations wher exceeding these rabenefit to water st other benefit, Rec concurrence. In situations of en these ramping rate Reclamation will operations and the reduction in flow.	Amo
she extent of incidental take is roughout the upper Sacramen eswick Dam to RBDD because. July 1 – March 31  o Releases reduced betweer Keswick releases > 6,000 releases may not exceed 1 more than 2.5% per hour.  o Keswick releases 4,000 c reductions in releases may per night, or 100 cfs per howard for the citis; reductions in releases betweer cfs; reductions in releases cfs per night.  o Variance allowed for floo	The extent of incidental take is delayed throughout the upper St delayed throughout the RDDD this spawn because of lower flows.  July 1 – March 31  Releases reduced between Keswick releases 96,000 releases may not exceed 1 more than 2.5% per hour.  Keswick releases 4,000 c reductions in releases may per night, or 100 cfs per h per night, or 100 cfs per h per night, or 100 cfs per h c Keswick releases between cfs; reductions in releases cfs per night.  Variance allowed for floo In situations where Reclamation water storage, a spec other benefit, Reclamation may concurrence.  In situations of emergency, Reclamation will provide to NI operations and their effects dur reduction in flow.	unt or Ext
The extent of incidental take is all redds dewatered throughout the upper Sacramento River from the Keswick Dam to RBDD because of lower flows.  July 1 – March 31  Releases reduced between sunset and sunrise Keswick releases > 6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour.  Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.  Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night.  Variance allowed for flood control releases.	The extent of incidental take is all adults stranded or delayed throughout the upper Sacramento River from the Keswick Dam to RBDD that cannot migrate or spawn because of lower flows.  July 1 – March 31 Releases reduced between sunset and sunrise Keswick releases > 6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour. Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour. Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night. Variance allowed for flood control releases. In situations where Reclamation determines that exceeding these ramping rates would provide a benefit to water storage, a species of concern, or som other benefit, Reclamation may do so with NMFS concurrence. In situations of emergency, Reclamation may exceed these ramping rates, and within two weeks Reclamation will provide to NMFS an assessment of operations and their effects during the emergency reduction in flow.	Amount or Extent of CCV Steelhead Take
all redds do to River from the of lower and cris, reducting symmetry and cris, reducting symmetry and symmetry from the total symmetry and the cris, reducting symmetry and the cris, reducting symmetry and the cris, and the cri	all adults s acramento it cannot m sunset and cfs, reducti 5% per nig 5% per nig 5s to 5,999 not exceed our. 3,250 cfs a may not ex may not ex eternine would provide so of conce do so with lamation m lamation m lamation m lamation m theo weeks ffS an asset ng the emengance of the solution of the solut	/ Steelhea
ewatered om the flows.  I sunrise ons in ht, and no cfs 1 200 cfs and 3,999 ceed 100 leases.	The extent of incidental take is all adults stranded or delayed throughout the upper Sacramento River from the Keswick Dam to RBDD that cannot migrate or spawn because of lower flows.  July 1 – March 31 Releases reduced between sunset and sunrise of Keswick releases > 6,000 cfs, reductions in releases may not exceed 15% per night, and no more than 2.5% per hour.  Keswick releases 4,000 cfs to 5,999 cfs reductions in releases may not exceed 200 cfs per night, or 100 cfs per hour.  Keswick releases may not exceed 200 cfs per night, or 100 cfs per hour.  Keswick releases may not exceed 100 cfs per night, or 100 cfs per hour.  Keswick releases between 3,250 cfs and 3,999 cfs; reductions in releases may not exceed 100 cfs per night.  Variance allowed for flood control releases.  In situations where Reclamation determines that exceeding these ramping rates would provide a benefit to water storage, a species of concern, or some other benefit, Reclamation may do so with NMFS concurrence.  In situations of emergency, Reclamation may exceed these ramping rates, and within two weeks Reclamation will provide to NMFS an assessment of operations and their effects during the emergency reduction in flow.	d Take

Ecological surrogates related to Shasta Summer Cold Water Pool Management.:  The extent of incidental take is the spawning habitat that exceeds 61°F (7DADM) in Tier 2 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan.	Sublethal: Temperatures in excess of 61°F can lead to stress, disease, bioenergetic depletion, or death among rearing Juveniles.	Reduced growth rate, reduced survival	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Low – Medium	January - July (May 15 - July)	Water Temperature Juveniles (Keswick Dam - RBDD)	Sacramento Shasta Tier 2 (Shasta Summer Cold Water Pool Management)
Ecological surrogates related to Shasta Summer Cold Water Pool Management.:  The extent of incidental take is the spawning habitat that exceeds 61 °F (7DADM) in Tier 1 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  For Tier 1 years the temperature target will be 53.5°F at CCR, with acceptable exceedances of no more than 5 consecutive days.  Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Sublethal: Temperatures in excess of 61°F can lead to stress, disease, bicenergetic depletion, or death among rearing Juveniles.	Reduced growth rate and survival probability	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Medium	January - July (May 15 - July)	Water Temperature Juveniles (Keswick Dam - RBDD)	Sacramento Shasta Tier 1 (Shasta Summer Cold Water Pool Management) Basalt and Porous Lava Diversity Group
In situations where Reclamation determines that exceeding these ramping rates would provide a benefit to water storage, a species of concern, or some other benefit, Reclamation may do so with NMFS concurrence.  In situations of emergency, Reclamation may exceed these ramping rates, and within two weeks Reclamation will provide to NMFS an assessment of operations and their effects during the emergency reduction in flow.  Incidental take of steelhead redds is expected to be proportional to the flow reduction such that expected take will be no greater than:  31% of redds at 3,250 cfs.  22% of redds at 4,500 cfs,  12% of redds at 5,000 cfs,							
Amount or Extent of CCV Steelhead Take	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division) Diversity Group

Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).  Ecological surrogates related to Shasta Summer Cold Water Pool Management.:  The extent of incidental take is the spawning habitat that exceeds 61 °F (7DADM) or 68°F (7DADM) in Tier 4 years, according to the following criteria:  Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances.  For Tier 4 years the temperature target will be determined in real-time with technical assistance from NMFS and USFWS.  Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	or death among rearing Juveniles.  Temperatures higher than 68°F (7DADM) would cause increased disease and decreased disease, and increased disease, impaired smoltification, reduced growth, and increased growth, and increased predation for late emigrating juveniles. Sublethal: Temperatures in excess of 61°F can lead to stress, disease, bioenergetic depletion, or death among rearing Juveniles. Temperatures higher than 68°F (7DADM) would cause increased disease and decreased disease and increased disease, impaired smoltification, reduced growth, and increased disease, impaired smoltification, reduced growth, and increased	Reduced growth, decreased survival survival Reduced growth rate Reduced growth, decreased survival	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Low	August - December (August - October 31)  January - July (May 15 - July)  August - December (August - October 31)	Migrating Adults (Keswick Dam - RBDD)  Water Temperature Tuveniles (Keswick Dam - RBDD)  Migrating Adults (Keswick Dam - RBDD)  RBDD)	Management)  Basalt and Porous Lava Diversity Group  Sacramento Shasta Tier 4 (Shasta Summer Cold Water Pool Management)  Basalt and Porous Lava Diversity Group
Ecological surrogates related to Shasta Summer Cold Water Pool Management.:  The extent of incidental take is the spawning habitat that exceeds 61°F (7DADM) or 68°F (7DADM) in Tier 3 years, according to the following criteria:	Sublethal: Temperatures in excess of 61°F can lead to stress, disease, bioenergetic depletion,	Reduced growth rate	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Low	January - July (May 15 - July)	Water Temperature Juveniles (Keswick Dam -	Upper Sacramento Shasta: Tier 3 (Shasta Summer Cold Water Pool
where Reclamation will meet the temperature target with allowable tolerances.  Shasta operations will remain consistent with performance metrics described in the Final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).							Basalt and Porous Lava Diversity Group
Amount or Extent of CCV Steelhead Take	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division) Diversity Group

Action Component (by division) Diversity Group	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
						predation for late emigrating juveniles.	
American River Northern Sierra Nevada Diversity Group	Water temperatures temperatures stage requirements, particularly occurring upstream of Watt Ave. during June through September	Year-round (May-October)	High	Medium	Reduced growth; Reduced survival	Sublethal: Physiological effects - increased susceptibility to disease (e.g., anal vent inflammation) and predation.	Ecological surrogate is temperature: The extent of take is habitat upstream of the Watt Avenue Bridge, where water temperature exceeds 65°F between May 15 and October 31, which occurs approximately 57 percent of days. When 65°F cannot be met, then temperature would be increased in 1 degree increments up to 68°F.
	Juvenile rearing Primarily upstream of Watt Ave. area						
American River Northern Sierra Nevada Diversity Group	Water temperatures warmer than life stage requirements, particularly occurring upstream of Watt Ave. in April and May  Embryo incubation Primarily upstream of Watt	Late-December - May (Late-December - May)	Modium	High	Reduced survival	Sublethal to lethal: Sublethal effects - reduced early life stage viability; direct mortality; restriction of life history diversity (i.e., directional selection against eggs deposited in Mar. and Apr.)	Ecological surrogate is temperature: The extent of incidental take is the stretch of the American River where the mean daily water temperature first begins to exceed 54°F, to the downstream extent of steelhead spawning habitat. This is expected to occur in most years during March, April, and May.
American River Northem Sierra Nevada Diversity Group	Folsom/Nimbus releases – flow fluctuations Spawning and Embryo incubation Primarily	Late-December - May (Late-December - May)	Modium	High	Reduced survival, reduced reproductive success	Lethal: Redd dewatering and isolation. Prohibiting successful completion of spawning Redd scour, resulting in egg mortality	Ecological surrogate is the frequency and duration of flows that result in redd dewatering, isolation, or redd scour.  Extent of incidental take is all embryos exposed to the stressors from redd dewatering flows, which have a medium annual frequency (25-75% of years).  Extent of take is expected to be limited to releases from Nimbus Dam that are greater than 50,000 cfs during egg incubation (i.e., January through May),

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American River	American River Northern Sierra Nevada Diversity Group	American River Northem Sierra Nevada Diversity Group	Diversity Group	Action Component (by division)
Nimbus Hatchery - hatchery O. mykiss spawning with natural- origin steelhead Spawning Primarily upstream of Watt Ave. area	Water temperatures warmer than life stage requirements, particularly occurring downstream of Watt Ave. during March through June Smolt emigration Throughout entire river	Folsom/Nimbus releases – flow fluctuations; low flows, particularly during late summer and early fall Juvenile rearing Primarily upstream of Watt Ave, area	upstream of Watt Ave. area	Stressor and Life Stage (location)
Late-December - early April (Late-December - early April)	January - June (January – June)	Year-round (Year-round)	Intersection)	Life Stage Timing (Work Window
High	Medium	Medium		Magnitude of Effect
High	High	Low		Weight of Evidence
Reduced genetic integrity	Reduced growth; Reduced survival	Reduced survival		Probable Change in Fitness
Sublethal: Reduced genetic diversity.	Sublethal: Physiological effects – reduced ability to successfully complete the smoltification process, increased susceptibility to predation	Lethal: Fry stranding and juvenile isolation; low flows limiting the availability of quality rearing habitat including predator refuge habitat		Type of Incidental Take
Ecological surrogate is steelhead release location: Extent of incidental take from Nimbus Fish Hatchery, for interim take coverage through 2024, is the release of juvenile steelhead downstream of the hatchery, to the Sunrise location (~RM 20). If the release location cannot be met then juvenile steelhead would be released between the Sunrise location and the Discovery Park location.	Ecological surrogate is temperature: The extent of incidental take is the stretch of the American River where the mean daily water temperature first begins to exceed 54°F, during the March through June period of smolt emigration. This is expected to occur in most years.	Ecological surrogate is the frequency and duration of flows that result in stranding and isolation, as well as flows insufficient to provide quality rearing habitat. Extent of incidental take is all juveniles exposed to the stressors from stranding and isolating flows, which have a medium annual frequency (25-75% of years).	which occurs approximately once every 5 years (NMFS 2018).	Amount or Extent of CCV Steelhead Take

Action Component (by division)	Stressor and Life Stage	Life Stage Timing (Work Window	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
Delta: DCC gate	Transit times	Juvenile migration	High	Medium to High - There	Reduced	Sublethal to lethal:	Ecological surrogates related to DCC gate operations:
operations		and rearing -		are a number of	survival	Increased mortality	(See Section 2.11.1.6.1)
Domilations from	Juveniles -	November – June		publications regarding the		due to increased	Gates open October through November, except if
Northwestern	Dar Dalta	(November –		Chinack salman in		migration times with	metil tricere are no longer avoided
Northwestern	Kiver -Delta	January, May21 –		Chinook salmon in		concurrent increased	until triggers are no longer exceeded.
Diversity Group		Julie)		Central Delta migratory		exposure to predators	
Basalt and				routes but not steelhead;			Gates closed Dec-Jan except for opening for up to 2
Porous Lava				routing and transit time			days each.
Diversity Group,				conclusions supported by			May 21 - June 15 14 days of closed gates; remainder
Nevada Diversity				modelling results.			of days gates are open.
Group							
Delta: DCC gate	Altered	Juvenile migration	High	High - There are a	Reduced	Minor to lethal:	Ecological surrogates related to DCC gate operations:
operations	Hydrodynamics	and rearing -		number of publications	fitness and/or	Increased mortality	(See Section 2.11.1.6.1)
	DCC location	(November – June		regarding the relative	gates are open	when gates are open due to changes in	Vates open October through November, except if KLCI or SCI trigger is exceeded, then gates are closed
Populations from	TO SECURE AND	January, May 21 -		salmon, but not steelhead		routing or transit time	until triggers are no longer exceeded.
Northwestern	Juveniles -	June)		in various North Delta		through interactions	
California	Sacramento			and Central Delta		with changes in river	Gates closed Dec-Jan except for opening for up to 2
Basalt and	Nivel -Delia			hydrodynamic		influence downstream	water quality events in drought conditions of up to 5-
Porous Lava				conclusions supported by		of DCC location and	May 21 – June 15 14 days of closed gates; remainder
Northern Sierra				modelling and physical testing results		gate operations	of days gates are open.
Nevada Diversity							
Group							
Delta: DCC Gate	Routing	Adult migration	Medium	Medium - tagging studies	Delayed	Minor:	Ecological surrogates related to DCC gate operations:
operations	Adults - Delta	(July – January,		Chinook through the	possible	the Mokelumne River	(See Seeing E.L.I.I.O.I)
Populations from		May 21-early		DCC when open. Should	reduction of	system when gates are	Gates open October through November, except if
Northwestern California		June)		apply to steelhead	spawning	opened, followed by	KLCI or SCI trigger is exceeded, then gates are closed
Diversity Group,						gates are closed. Gate	until triggers are no longer exceeded.
Basalt and						operations for water	Gates closed Dec-Jan except for opening for up to 2
Diversity Group,						quanty concerns	water quality events in drought conditions of up to 5-
Northern Sierra							days each.
Nevada Diversity							May 21 – June 13 14 days of closed gates; remainder of days gates are open.
CIOND							Gates open June 16 – September 30.
Delta: CVP/SWP	Altered	Juvenile migration	Medium	Medium to High - effects	Reduced	Sublethal to lethal:	Ecological surrogates related to OMR management
South Delta	hydrodynamics in south Delta/	and rearing -		of hydrodynamics well	survival,	in condition due to	OMP flows more negative than 5 000 of prior to
Exports	routing	(November –		Effects of hydrodynamics	growth	migratory delays in	January 1.
		June)		on salmonid migrations		response to altered	

Action Component (by division) Diversity Group	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
Populations from all Diversity Groups	Juveniles - Sacramento River -Delta			in south Delta less certain.		hydrodynamics in channels of the south Delta. Loss of appropriate migratory cues. Delays increase transit time and exposure to predators, poor water quality, and contaminants when OMR flows are more negative than -5,000 cfs	OMR restrictions from ~January 1 through June 15 (specific dates depend on species-specific OMR onset and offramp). OMR limited to no more negative than -5,000 cfs except during Storm flex actions with some exceptions
Delta: CVP/SWP South Delta Exports Populations from all Diversity Groups	Entrainment and loss at the south Delta export facilities Juveniles - Delta	Juvenile migration and rearing - November – June	Medium - sustained high frequency exposure on small proportion of population	High - Numerous studies have evaluated the efficiency of the screening facilities, predation, as well as survival through the facilities	Reduced survival	Sublethal to lethal: Mortality of fish occurs during the salvage process, resulting in the loss of fish entrained into the facilities.	December – March: Loss of 1,885 steelhead April – June 15: Loss of 2,070 steelhead Based on the maximum number of fish lost annually between 2010 and 2018 for each time period, plus 20 percent.
Delta: South Delta Agricultural Barriers Populations from all Diversity Groups but primarily the Southern Sierra Nevada Diversity Group	Transit times Juveniles - Sacramento River -Delta	Juvenile migration and rearing - November – June (May –June)	Medium - installation of barriers occurs during Steelhead migratory period, exposure to the barriers is expected to be low for Sacramento River basin SH, high for SH.	Medium - several studies have indicated that the barriers increase transit time through the south Delta and increase predation risks. Timing of spring-run in the south Delta channels is well documented by salvage records.	Reduced survival	Sublethal to lethal: Delayed migration and increased transit times with potential for increased mortality due to increased exposure to predators when migrating through routes with barriers.	Ecological surrogates related to barrier operations: (See Section 2.11.1.6.8) Installation of barriers no earlier than May 1. May 16 to May31, tidal flaps on culverts tied open. At least 1 tidal flap tied open if water temperature < 22°C. Sept 15 notch in barrier weirs or flashboard removal Sept 15 No agricultural barriers operations after Nov 30.
Delta: South Delta Agricultural Barriers Southern Sierra Nevada Diversity Groups	Transit times Adults - Delta	Adult migration - July -January (south Delta - SJ River population) (July – November)	Medium - installation of barriers occurs during adult SH migratory period, exposure to the barriers is expected to be high for SJR basin population SH.	Medium - several studies have indicated that the barriers increase transit time through the south Delta and increase predation risks. Timing of spring-run in the south Delta channels is well documented by salvage records.	Reduced survival	Sublethal to lethal: Delayed migration and increased transit times with potential for increased mortality due to increased exposure to warmer water conditions while moving upriver over barriers	Ecological surrogates related to barrier operations: (See Section 2.11.1.6.8) Installation of barriers no earlier than May 1. May 16 to May31, tidal flaps on culverts tied open. At least 1 tidal flap tied open if water temperature < 22°C. Sept 15 notch in barrier weirs or flashboard removal Sept 15 No agricultural barriers operations after Nov 30.

Action Component (by division) Diversity Group	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
Delta: DCC gate	Increased	Juvenile migration	Low - sustained	High - numerous studies	Reduced	Lethal:	See SWP/CVP Salvage operations
operations Populations from	loss at the South	and rearing - November - June	population effects on	notential risk to	survival	entrained fish at the	
Northwestern	Delta Exports	(November-	proportion of the	salmonids entering the		CVP and SWP fish	
California	facilities	January, May21 –	population present in	Delta interior and		salvage facilities	
Basalt and	Juveniles -		j	entrainment at the fish			
Diversity Group.	River -Delta			salvage facilities			
Northern Sierra							
Nevada Diversity Group							
Delta: North Bay	Routing	Juvenile migration	Low - very small	Medium - few salmonids	Reduced	Minor:	Ecological surrogate related to water diversion rate at
Aqueduct	Juveniles -	and rearing - November - June	proportion of population will be	observed in regional monitoring efforts in the	survival	Increased mortality due to routing into the	Barker Slough Pumping Plant: (See Section 2.11.1.6.2)
Populations from	Sacramento	(November –	present in Barker	past. No fish observed		channels of the	Diversion up to 175 cfs
Northwestern California	River -Delta	June)	Slough, low impacts of diversion volumes	behind screens in monitoring efforts.		Lindsey Slough/ Barker Slough region	
Diversity Group,			on hydrodynamics	140		10 m	
Porone I ava							
Diversity Group,							
Northern Sierra							
Nevada Diversity Group							
Delta: North Bay	Entrainment and	Juvenile migration	Low - screens are	High - monitoring has	Minimal	Minor:	Ecological surrogate related to water diversion rate at
Aqueduct	impingement onto fish screens	and rearing - November - June	designed for delta smelt criteria, few	few observations of salmonids at this location,	change in fitness	Injury and Mortality caused by entrainment	Barker Slough Pumping Plant: (See Section 2.11.1.6.2)
Populations		(November -	salmonids expected	multiple studies regarding		and/or impingement on	Diversion up to 175 cfs
from	Juveniles -	June)	to be present at	efficiency of positive		the screens at the	
Northwestern California	Sacramento River -Delta		screen location	barrier fish screens		North Bay Aqueduct, Barker Slough	
Diversity Group,						Pumping Plant intake.	
Porous Lava							
Diversity Group, Northern Sierra							
Nevada Diversity							
Group Delta: North Bay	Entrainment	Juvenile migration	Low - fish unlikely to	Low - No reports or	Minimal	Sublethal to lethal:	Un to 5 listed invenile salmonids (which may include
Aqueduct	during sediment	and rearing -	be in area of screens	studies available	change in	Injury or death due to	CCV steelhead) per year – take is likely to be lethal.
79	cleaning	November – June	during cleaning		fitness	entrainment into	82
Populations	1	(November –				dredge or impingement	
Northwestern	Sacramento	June)				onto fish screens	
California	River -Delta						

 Incidental take of up to 50 adult or juvenile CCV steelhead cumulative, with no more than 5 mortalities. 							
Over the two year Predator Fish Relocation Study:					(January - June		
steelhead cumulative, with no more than 5 mortalities.	entanglement/entrapm ent in sampling gear		3	PA's duration	and rearing - November - June	juveniles- Delta	all Diversity Groups
 Incidental take of up to 50 adult or juvenile CCV 	due to		on sampling methods.	three years of the	Juvenile migration	Adults and	Populations from
Over the two-year Predator Reduction Electrofishing Study:	Sublethal to lethal: Increased vulnerability	Reduced survival	Medium - Several reports from previous predator	Low - infrequent sampling Study	Adult migration: July – May	Capture in sampling gear	removal studies
	Slough where predation is likely to be elevated		been observed in historical monitoring.				Cionba
	due to routing into the	predation.	fish are observed in front				all Diversity
	increased mortality	increased	screens, however some	intake	June)	River -Delta	Populations from
	with potential for	migration or	entrained through the	the fish screens and	(November –	Sacramento	
Diversion up to 350 cfs	increased transit times	delay in	indicate that no fish are	be in the vicinity of	November - June	Juveniles -	water diversions
Rock Slough Pumping Plant (See Section 2.11.1.6.4)	Delayed migration and	fitness due to	monitoring reports	of fish are likely to	and rearing -	Routing	Rock Slough
Englacial currents related to motor dimercian esta at	Subjected to lethel.	Padward	Madium annual	I am amall numbers	Impanile microtion	Douting	CCWD
							Group
							Nevada Diversity
							Northern Sierra
							Diversity Grown
						Kiver - Deita	Basait and
						Sacramento	Diversity Group,
						Juveniles -	Camornia
	during weed removal				June)	•	Northwestern
	by grappling hooks				(November –	cleaning	from
	impingement, capture	fitness		during cleaning	November – June	aquatic weed	Populations
CCV steelhead) per year – take is likely to be lethal.	Injury or death due to	change in	studies available	be in area of screens	and rearing -	capture during	Aqueduct
Up to 5 listed juvenile salmonids (which may include	Sublethal to lethal:	Minimal	Low - No reports or	Low - fish unlikely to	Juvenile migration	Impingement/	Delta: North Bay
							Group
							Nevada Diversity
							Northern Sierra
							Diversity Group
							Porone I ava
							Diversity Group,
		Fittless			Intersection)	(IOCALIOII)	Diversity Group
Amount or Extent of CCV Steelnead Take	Take	Change in	weight of Evidence	Magnitude of Effect	Window	(location)	division)
Amount of Fetont of COV Stolland Tolla	Type of Incidental	Changin	Weight of Friday	Maniful of Effect	Timing (Work	Tife Strand	Component (by
		Dankakla			Life Stage	Student and	Action

Action Component (by division) Diversity Group	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
Delta: CVP Improvements	CO2 Injections Juveniles -	Juvenile migration and rearing - Nov	Low	Medium – several studies show effectiveness of	Reduced fitness	Sublethal to lethal: Small increase in	Operations of CO2 injector covered under SWP/CVP export operations for salvage and loss.
all Diversity Groups	River – Delta (TFCF	(Nov – June)		predators and sensitivity of smaller fish to CO2		mortality due to CO2 exposure during	
Cioups	Juveniles - Sacramento River -Delta			exposure		predator clean outs of secondary channel	
Delta: Suisun Marsh Roaring River	Temporary change in water flow/water	Adult migration (July – May) and invenile	Low	Low- data on steelhead migration and rearing in Suisun Marsh is low	Minimal	Minor: During the annual 70 to 80 days of periodic	Ecological surrogate based on the SMSCG operations: (See Section 2.11.1.6.6) June – Sentember - no more than 60 days of gate
Distribution System Food	quality (20 days Oct-May, 60	emigration (Nov – June).		Susui Maisi is isw		operation, individual adult steelhead may be	closure. Oct-May – no more than 20 days of gate closure.
Subsidy Studies Populations from	days June-Sept)	(Nov - June).				delayed in their	Boat locks are kept open except as needed for boat
all Diversity	Adults and					spawning migration from a few hours to several days. Inveniles	Gate closures only on flood tides
	migrating through the					may be delayed on their downstream	
	Delta.					movements by closed gates for several hours while gates are closed on flood tides.	
Delta: Water Transfers Populations from	Stranding following end of transfer releases	Juvenile rearing, holding, and migration upper	Low -changes in river flow related to transfers not expected	Medium – several studies conducted on Chinook salmon stranding in upper	Reduced survival due to risk of	Sublethal to lethal: Isolation and stranding in side channels and	Ecological surrogates related to water transfers (See Section 2.11.1.6.5) Transfers allowed only July through November
Northwestern California Diversity Group,	THE POPULATION OF THE POPULATI	Sacramento River - Year -round (July -November)	to change river elevations substantially,	Sacramento River.	stranding as flows recede	pools following reduction of reservoir releases.	Maximum volumes of water transfers restricted to permitted amounts. (See Section 2.11.1.6.5) Implementation of ramping rates for reduction of releases from Keswick Reservoir to minimize
Porous Lava Diversity Group, Northern Sierra Nevada Diversity Group							stranding. (See Section 2.5.5.6 and Upper Sacramento/ Shasta Water Minimum Flows)
San Joaquin Rdver PA Conditions	Lack of overbank flow to inundate rearing habitat	December-May (year-round, but particularly in May and June)	Medium to High	Medium	Reduced growth rates; Reduced survival	Sublethal to lethal: Reduced food supply; suppressed growth rates; starvation; loss	Ecological surrogate is flows. The extent of incidental take is that associated with implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team).
Southern Sierra Nevada Diversity Group	Juvenile rearing Confluence of Stanislaus to Mossdale					to predation; poor energetics; indirect stress effects, smaller size at time of emigration;	
						emgration,	

Reduction in rearing habitat complexity due to reduction in channel forming and flows poor flows poor flows poor flows poor flows poor flows to Mossdale Springtime water temperatures warmer than life history stage requirements, primarily March-May Juvenile migration / outmigration outmigration Confluence of Stanislaus to Mossdale Suboptimal flow Juvenile migration flow flowering flowering flow flowering flow flowering flowering flow flowering flowerin	Action Component (by division) Diversity Group	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
ocomplexity due reservoir releases; no sistern or reduction in most likely winter from Sitern Diversity flows provided in and spring, and spring with the provided provided in the provided in the provided in and spring. The provided in the provided in the provided in and spring, and spring with the provided in and spring. The provided in and spring with the provided in and spring with the provided in and spring. The provided in and spring with the provided in a provided in the provided in a provided in the provided in a provided in the provided in the provided in the provided in a provided in the provided in a provided in the provided internal stress and in Delta; and breastly in the production through the provided internal stress. Provided in the provided internal provided internal stress and in Delta; and breastly in the production in the provided internal stress. The provided internal stress and in Delta; and breastly in the production in the provided internal stress. The provided internal stress and in Delta; and breastly in the production in the provided internal stress. The provided internal stress and in Delta; and breastly in the production in the provided internal stress. The provided internal stress and in Delta; and breastly in the production in the provided internal stress and in Delta; and the provided internal stress and in Delta; and the	San Joaquin River PA	Reduction in rearing habitat	December-May (flood control and	Medium to High	Medium	Reduced growth rates;	Sublethal to lethal: Reduced food supply;	The ecological surrogate is flows. The extent of incidental take is that associated with
a Diversity flows a Diversity flows a Diversity flows but and spring. Luvenile rearing Confluence of Stansistius to March-May) December-May a Diversity primarily March- hatory stage myster Diversity primarily March- hatory December-May December-May Medium to High Medium to Hi	Conditions	complexity due to reduction in	reservoir releases; most likely winter			Reduced survival	suppressed growth rates; starvation; loss	implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team).
Liversity Liversity Liversity Liversity Liversity Liversity PA Liversity Massylatas to Massdale Machi-June) Machi-June Mac	Southern Sierra	channel forming	and spring,				to predation; poor	300
Louenile rearing Confinence of Stanislaus to Medium to High High Medium to High High Medium to High High High Medium to High H	Group	IIOWS	round)				stress effects, smaller	
Confluence of Samislaus to Samis	and the state of t	Juvenile rearing	1907 1900 1000				size at time of	
Medium to High Medium to High Wedium to High Wareh-June) PA Juvenile Ingration / Outhornec of Stanislaus to Mossdale Wareh-June) Wareh-June Wedium to High		Confluence of					emigration;	
Springitine water December-May) PA Interpretatures Int		Mossdale						
ions warner than life history stage requirements, a Diversity mistery requirements, and present primarily March-life history stage requirements. The migration out-migration out-migrati	San Joaquin River: PA	Springtime water temperatures	December-May (March-May)	Medium to High	Medium to High	Reduced growth rates:	Sublethal to lethal: Metabolic stress:	The ecological surrogate is water temperature. Extent of incidental take is the section of the San
Interest primarily March- requirements, a Diversity primarily parchers and inject requirements, primarily in May Insperation Reduced primarily March- Medium to High Medium Medium to High Medium Medium to High Medium Medium to High Medium Medium Medium Medium to High Medium Medium survival; survival; survival; primarily in May Mossdale Mossdale Mossdale Mossdale Mossdale Mossdale Mossdale Medium Mediu	Conditions	warmer than life				Reduced	starvation; loss to	Joaquin River from the confluence of Stanislaus to
Inversity primarily March- May Invenile Ingration / out-	•	history stage				survival	predation; indirect	Mossdale when this life stage of the listed species is
May May May May May May May May	Nevada Diversity	requirements,					stress effects, poor	present, with observed water temperatures within the
Juvenile migration / out- Mossdale Suboptimal flow February - June Medium to High Medium Reduced Sublethal to lethal: survival; Failure to escape river Reduced Merch-June Medium Medium Reduced Sublethal to lethal: survival; Failure to escape river Reduced Merch-June Medium Medium Medium Medium Medium Medium Medium migration Medium Medium Medium Medium Medium Medium migration Medium Medium Medium Medium Reduced Imining Medium misterra Medium Medium Medium Reduced Medium misterra February - June Medium Medium Reduced Giversity in misterra Medium Medium Reduced Medium misterra Medium Medium Medium misterra Medium Medium Medium misterra Medium misterr	Group	May						
migration out- migration Confluence of Stanislaus to Mossdale Suboptimal flow Invenile ions migration out- mig		Juvenile						
Confluence of Stanislaus to Mossdale Suboptimal flow Ingration / out- migration / out- migration / Stanislaus to March-June) Mossdale Diversity Mossdale Suboptimal flow (March-June) March-June) Mossdale Diversity Mossdale Moss		migration / out-						
Mossdale Suboptimal flow Medium to High Juvenile ions migration / out- maisilaus to Suboptimal flow Juvenile ions migration / out- migration Mossdale Diversity Stanislaus to Suboptimal flow Medium to High Juvenile ions Migration / out- migration Confluence of Stanislaus to Mossdale Mossdale Water Keduced of Stanislaus to Mossdale February – June Medium Medium Medium Medium Medium Medium Medium Medium Medium Medium Medium Medium Medium Reduced in Delta; thermal stress; thermal stres		Confluence of						
Suboptimal flow PA Juvenile ions migration / out- my Sierra Confluence of a Diversity Stanislaus to Mossdale PA Water PA Water rn Sierra bistory stage rn Sierra primarily in May and June Juvenile out- migration / out- migration / out- migration / out- my sierra primarily in May and June Medium to High Medium Medium to High Medium to High Medium to High Sublethal to High Sublethal to High Sublethal to High Medium to escape river with survival; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation warmer than life history stage requirements, and June warmer than life history stage requirements, and June warmer than life history stage requirements, and June warmer than life history stage requirements, warmer than life history stage requirements, and June warmer than life history stage requirements, and June warmer than life history stage requirements, warmer than life history stage there warmer than life history stage at lower river size at lower river outming warmer than life history stage there was a lower river outming warmer than life history stage there was a lower river outming warmer than life history stage there was a lower river outming warmer than life history stage there was a lower river outming warmer than life history stage there was a lower river outming warmer than life history stage there was a lower river outming warmer than life history stage there was a lower river was a lo		Stanislaus to Mossdale						
PA Juvenile (March-June) (March-June) survival; Failure to escape river Reduced of Effort temperatures and in Delta; migration / out- gration	San Joaquin	Suboptimal flow	February – June	Medium to High	Medium	Reduced	Sublethal to lethal:	The ecological surrogate is flows.
migration Confluence of Stanislaus to Mossdale Water PA temperatures m Sierra a Diversity an Diversity and June Juvenile out- migration migration Confluence of Stanislaus to Mossdale Water PA temperatures primarily in May and June Medium Medi	Conditions	Juvenile migration / out-	(March-June)			survival; Reduced	Failure to escape river before temperatures	The extent of incidental take is that associated with implementation of the SRP minimum flows (as
A Diversity Stanislaus to Stanislaus to Mossdale Stanislaus to Stanislaus		migration				diversity in	rise at lower river	revised by the Stanislaus Watershed Team).
Mossdale Water PA temperatures ions warmer than life history stage requirements, primarily in May and June Juvenile out- migration Mossdale Reduced bate (year-round) Medium Medium Medium Medium Medium Medium Reduced Giversity in outmigration viming timing whernal stress; wiming thermal stress;	Nevada Diversity	Stanislaus to				timing	thermal stress:	
Water February – June Medium Medium Reduced Sublethal: PA warmer than life history stage requirements, a Diversity and June Juvenile outmigration Water February – June Medium Medium Medium Reduced Sublethal: predation for exacpe river diversity in marily in May and June Medium Medium Medium Reduced Sublethal: predation friver diversity in outmigration timing thermal stress; thermal stress;	Group	Mossdale				o	misdirection through	
Water February – June Medium Medium Reduced predation PA temperatures warmer than life history stage requirements, primarily in May and June Juvenile outmigration Water February – June Medium Medium Reduced Sublethal: Failure to escape river Reduced diversity in outmigration temperatures diversity in reaches and in Delta; timing thermal stress;							increased residence	
PA temperatures (year-round) (year-round) Medium Medium survival; Failure to escape river Reduced history stage requirements, a Diversity and June Juvenile outmigration Medium Medium Medium survival; Failure to escape river Reduced diversity in outmigration timing thermal stress;							predation	
warmer than life history stage n Sierra a Diversity and June In Sierra before temperatures diversity in rise at lower river outmigration reaches and in Delta; timing thermal stress;	San Joaquin	Water	February – June (year-round)	Medium	Medium	Reduced survival:	Sublethal: Failure to escape river	The ecological surrogate is water temperature. Extent of incidental take is the section of the San
history stage diversity in rise at lower river requirements, primarily in May and June Juvenile outmigration migration	Conditions	warmer than life	,			Reduced	before temperatures	Joaquin River from the confluence of Stanislaus to
a Diversity primarily in May thermal stress; Juvenile outmigration	Couthon Cione	history stage				diversity in	rise at lower river	Mossdale when this life stage of the listed species is
and June Juvenile out- migration	Nevada Diversity	primarily in May				timing	thermal stress;	tolerances described in Section 2.11.1.5.1.1.
Juvenile out- migration	Group	and June						
iiiigiunoii		Juvenile out-						

Action Component (by division) Diversity Group	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
	Confluence of Stanislaus to Mossdale						
East Side Division: Seasonal operations and Stepped Release Plan Southern Sierra Nevada Diversity Group	Excessive fines in spawning gravel resulting from lack of overbank flow Egg incubation and emergence Goodwin Dam to Orange Blossom Bridge	December-June (potentially year-round)	High	Medium	Reduced survival	Lethal: Egg mortality from lack of interstitial flow; egg mortality from smothering by nest-building activities of other CCV steelhead or fall-run; suppressed growth rates	The ecological surrogate is flows. The extent of incidental take is that associated with implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team). Excessive fines in spawning habitat may result in poor spawning bed conditions, as the proposed frequency of channel mobilizing flows of 5,000 cfs (which will typically occur during flows on the standard releases) may not result in mobilizing flows at higher levels which perform greater geomorphic work.
East Side Division: Seasonal operations and Stepped Release	Water temperatures warmer than life history stage requirements	December-June (year-round)	High	Medium	Reduced survival	Sublethal to lethal: Egg mortality, Embryonic deformities	The ecological surrogate is water temperature. Extent of incidental take is the section of the Stanislaus River from Goodwin Dam to OBB when this life stage of the listed species is present, with observed water temperatures within the tolerances described in Section 2 11 1 5 1 1
Southern Sierra Nevada Diversity Group	Egg incubation and emergence Goodwin Dam to Orange Blossom Bridge						
East Side Division: Seasonal operations and Stepped Release Plan Southern Sierra Nevada Diversity Group	Suboptimal flow Smolt emigration Stanislaus River	January – June (March-June)	Medium to High	Medium	Reduced survival; Reduced diversity	Sublethal to lethal: Failure to escape river before temperatures rise at lower river reaches and in Delta; thermal stress; misdirection through Delta leading to increased residence time and higher risk of predation	The ecological surrogate is flows. The extent of incidental take is that associated with implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team).
East Side Division: Seasonal operations and Stepped Release Plan	Lack of overbank flow to inundate rearing habitat Juvenile rearing	Year round (year-round, particularly in May and June)	Medium to High	Medium	Reduced growth rates; Reduced survival	Sublethal to lethal: Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect stress effects, smaller	The ecological surrogate is flows. The extent of incidental take is that associated with implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team).

Action Component (by division) Diversity Group	Stressor and Life Stage (location)	Life Stage Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Probable Change in Fitness	Type of Incidental Take	Amount or Extent of CCV Steelhead Take
Southern Sierra Nevada Diversity Group	Goodwin Dam to Orange Blossom Bridge					size at time of emigration;	
East Side Division: Seasonal operations and Stepped Release Plan	Reduction in rearing habitat complexity due to reduction in channel forming flows	Year round (flood control and reservoir releases; most likely winter and spring, potentially year-	Medium to High	Medium	Reduced growth rates; Reduced survival	Sublethal to lethal: Reduced food supply; suppressed growth rates; starvation; loss to predation; poor energetics; indirect	The ecological surrogate is flows. The extent of incidental take is that associated with implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team).
Southern Sierra Nevada Diversity Group	Juvenile rearing Goodwin Dam to Orange Blossom Bridge	ļ				size at time of emigration;	
East Side Division: Seasonal operations and Stepped Release	End of summer water temperatures warmer than life history stage	Year round, with temperature stress likely most acute July-September (June-September)	Medium to High	Medium to High	Reduced growth rates; Reduced survival	Sublethal to lethal: Metabolic stress; starvation; loss to predation; indirect stress effects, poor	The ecological surrogate is water temperature. Extent of incidental take is the section of the Stanislaus River from Goodwin Dam to OBB when this life stage of the listed species is present, with observed water temperatures within the tolerances
Southern Sierra Nevada Diversity Group	Juvenile rearing Goodwin Dam to Orange Blossom Bridge						
East Side Division: Seasonal operations and Stepped Release Plan Southern Sierra Nevada Diversity Group	Excessive fines in spawning gravel resulting from lack of overbank flow Spawning Goodwin Dam to Orange Blossom Bridge	December- February (potentially year- round)	Modium	Medium	Reduced reproductive success	Sublethal: Reduced suitable spawning habitat; For individual: increased energy cost to attempt to "clean" excess fine material from spawning site	The ecological surrogate is flows. The extent of incidental take is that associated with implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team). Excessive fines in spawning habitat may result in poor spawning bed conditions, as the proposed frequency of channel mobilizing flows of 5,000 cfs (which will typically occur during flood control releases) may not result in mobilizing flows at higher levels which perform greater geomorphic work.
East Side Division: Seasonal operations and Stepped Release Plan	Water temperatures warmer than life history stage requirements (March – June)	January – June (year-round)	Low	Medium	Reduced diversity	Sublethal: Missing triggers to elect anadromous life history; failure to escape river before temperatures rise at lower river reaches	The ecological surrogate is water temperature. Extent of incidental take is the section of the Stanislaus River from Goodwin Dam to OBB when this life stage of the listed species is present, with observed water temperatures within the tolerances described in Section 2.11.1.5.1.1).

		temperature- related effects					
		water					
		Reduced					
		Reduced					
Operations)		reductions) to					
Seasonal Operations and other Core Water		(export					
(export operations, Salinity Control Gate Operations,		survival					
the effects of action components described above		Benefits to		to Medium		juvenile rearing	Habitat Action
Take is exempted to the extent that it is covered under	Sublethal to lethal	Variable –	Low	Variable - Beneficial	Fall-Summer	Egg incubation,	Delta Smelt
	reduced fitness levels.						
	result in delayed						
	racult in delayed						dionb
	approximately 1-2						Nevada Diversity
	difference of						Southern Sierra
	period of time, and a						(OBB)
	would be for a short						Blossom Bridge
	dissolved oxygen. This				3		to Orange
	exposed to reduced				summer)		miles upstream
	months, and may be				DO most often in		(7.0 mg/L) 31
	during summer				resulting in low	in summer	Requirement -
	migrating through				requirement,	upstream of OBB	Oxygen
	however, few may be				(year-round DO	steelhead	Dissolved
Goodwin Dam to OBB.	upstream of OBB,				area	Juvenile	Stanislaus River
Extent of take is dissolved oxygen 7.0 or higher from	primarily present				upstream of action		Alteration of
concentration.	Juvenile steelhead are				primarily present	DO Barrier	Division:
The ecological surrogate is dissolved oxygen	Minor:	Minimal	Medium	Low	Juvenile steelhead	Temporary Low	East Side
						at inouti	
						Stanislaus River	Group
	stress;					and emigration	Nevada Diversity
	and in Delta; thermal					Smoltification	Southern Sierra
		radies			Intersection)	(location)	Diversity Group
Amount or Extent of CCV Steelnead Take	Take	Change in	weight of Evidence	Magnitude of Effect	Window	Life Stage	division)
	Type of Incidental	rropable			Timing (Work	Stressor and	Component (by
	A STATE OF THE STA	D.,L.L.			Life Stage	04	Action

2.11.1.4 sDPS Green Sturgeon Incidental Take Table

Table 2.11.1-4. sDPS Green Sturgeon Incidental Take

Upper Sacramento Shasta: Tier 2 (Shasta Summer Cold Water Pool Management)	Upper Sacramento Shasta: Tier 1 (Shasta Summer Cold Water Pool Management)	Action Component (by division)
Water Temperature Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Water Temperature Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Stressor and Life Stage (location)
April - July (May 15 - July), May - August (May 15 - August)	April - July (May 15 - July), May - August (May 15 - August)	Life Stage Timing (Work Window Intersection)
Low	Medium	Magnitude of Effect
Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Weight of Evidence
Reduced reproductive success	Reduced reproductive success	Probable Change in Fitness
Sublethal: PA temperature ranges from temps associated with abnormal development of eggs and larvae (sublethal) to decrease in egg survival (lethal) in lab studies.	Sublethal: PA temperature ranges from temps associated with abnormal development of eggs and larvae (sublethal) to decrease in egg survival (lethal) in lab studies.	Type of Incidental Take
Ecological surrogates related to Shasta Summer Cold Water Pool Management.: The extent of incidental take is the spawning habitat that exceeds 63.5°F in Tier 2 years, according to the following criteria: Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances. Shasta operations will remain consistent with performance metrics described in the Final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Ecological surrogates related to Shasta Summer Cold Water Pool Management.: The extent of incidental take is the spawning habitat that exceeds 63.5°F in Tier 1 years, according to the following criteria: Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances. For Tier 1 years the temperature target will be 53.5°F at CCR, with acceptable exceedances of no more than 5 consecutive days. Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Amount or Extent of sDPS Green Sturgeon Take

		
Upper Sacramento Shasta: Tier 4 (Shasta Summer Cold Water Pool Management)	Upper Sacramento Shasta; Tier 3 (Shasta Summer Cold Water Pool Management)	Action Component (by division)
Water Temperature Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Water Temperature Spawning Adults, Eggs/Larval, (BSF gauge - Hamilton City)	Stressor and Life Stage (location)
April - July (May 15 - July), May - August (May 15 - August)	April - July (May 15 - July), May - August (May 15 - August)	Life Stage Timing (Work Window Intersection)
Medium, High	Low	Magnitude of Effect
Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Medium: Supported by multiple scientific and technical publications, however not specific to the region and species.	Weight of Evidence
Reduced reproductive success, Reduced survival probability	Reduced reproductive success	Probable Change in Fitness
Sublethal to lethal: PA temperature ranges from temps associated with abnormal development of eggs and larvae (sublethal) to decrease in egg survival (lethal) in lab studies.	Sublethal: PA temperature ranges from temps associated with abnormal development of eggs and larvae (sublethal) to decrease in egg survival (lethal) in lab studies.	Type of Incidental Take
Ecological surrogates related to Shasta Summer Cold Water Pool Management.: The extent of incidental take is the spawning habitat that exceeds 63.5°F, or 71.5°F in Tier 4 years, according to the following criteria: Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances. For Tier 4 years the temperature target will be determined in real-time with technical assistance from NMFS and USFWS. Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Ecological surrogates related to Shasta Summer Cold Water Pool Management.: The extent of incidental take is the spawning habitat that exceeds 63.5°F, or 71.5°F in Tier 3 years, according to the following criteria: Shasta operations will remain consistent with the annual Shasta Cold Water Management Plan, where Reclamation will meet the temperature target with allowable tolerances. Shasta operations will remain consistent with performance metrics described in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).	Amount or Extent of sDPS Green Sturgeon Take

Gates closed Dec-Jan except for opening for up to 2 water quality events in drought conditions of up to 5-days each May 21 – June 15 14 days of closed gates; remainder of days gates are open. Gates open June 16 –November 30 with few	When gates are open, movement into the Mokelumne River system from the Sacramento River increased routing distance to the western Delta	negative change in fitness, potential exposure to lower quality rearing habitat	green sturgeon migratory movements through the DCC		(May 21- January 30)	Juveniles - Sacramento River - Delta	Орониона
exceptions. Ecological surrogates related to DCC gate contraines: (See Section 2.11.1.6.1)	Minor:	Uncertain,	Low - There is little	Medium	Year round	Routing	Delta: DCC Gate
2591	Minor: When gates are open movement into and through the Mokelumne River system, increased transit distance to/from western Delta	Delayed migration, possible reduction of spawning success	Low - There is little information regarding green sturgeon migratory movements through the DCC	Medium	Year round presence (May 21- January 30)	Routing Adults - Sacramento River - Delta	Delta DCC Gate operations -
Cumulative annual salvage of 74 sDPS green sturgeon.	Sublethal to lethal: Mortality of fish occurs during the salvage process, resulting in the loss of fish entrained into the facilities, unknown vulnerability to predation or loss through louvers.	Reduced survival	High Medium - studies have evaluated the effect of screening facilities, and predation on green sturgeon, but not specifically related to loss, as well as survival through at the facilities	Medium - sustained high frequency exposure on small proportion of population	Year round presence (Year round presence)	Entrainment and loss at the South Delta export facilities Juveniles - Sacramento River -Delta	Detta CVP/SWP South Delta Exports
	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)

Action	Stressor and	Life Stage			Probable	Tues of Incidental	Amount of Festive of DBC Caron Charge
Component (by division)	Life Stage (location)	Timing (Work Window Intersection)	Magnitude of Effect	Weight of Evidence	Change in Fitness	Type of Incidental Take	Amount or Extent of sDPS Green Sturgeon Take
Delta: DCC Gate operations	Transit times	Year round presence	Medium	Low - There is little information regarding	Uncertain, minimal	Minor:	Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1)
р		(May 21- January		green sturgeon migratory	negative	times to western Delta	Gates closed Dec-Jan except for opening for up to
	Juveniles - Sacramento River -Delta	30)		DCC - Green sturgeon juveniles rear within the	fitness,	when fish migrate through the delta	2 water quality events in drought conditions of up to 5 days each
				waters of the Delta for up to 3 years.	exposure to lower quality	interior	May 21 – June 15 14 days of closed gates; remainder of days gates are open.
					ď		Gates open June 16 -November 30 with few exceptions.
Delta: DCC Gate operations	Altered Hydrodynamics	Year round presence	Medium	Low - There is little information regarding	Uncertain, minimal	Minor:	Ecological surrogates related to DCC gate operations: (See Section 2.11.1.6.1)
	DCC location	(May 21- January 30)		green sturgeon migratory movements through the DCC - Green sturgeon inventiles rear within the	negative change in fitness,	sacramento extends farther downstream,	Gates closed Dec-Jan except for opening for up to 2 water quality events in drought conditions of up to 5-days each
	Juveniles - Sacramento			waters of the Delta for up to 3 years.	exposure to lower quality	less tidal influence, faster transit times. When gates are	May 21 – June 15 14 days of closed gates; remainder of days gates are open.
	River-Delia				a	opened, more routing into Delta interior	Gates open June 16 -November 30 with few exceptions.
Delta: South Delta	Transit times	Year round presence	Medium - installation of barriers occurs	Medium - several studies have indicated that the	Reduced survival	Sublethal to lethal:	Ecological surrogates related to barrier operations: (See Section 2.11.1.6.8)
Barriers	Juveniles - South	(May 21- January 30)	April/May through the end of November	time through the South Delta and increase		increased transit times with potential for	May 16 to May31, tidal flaps on culverts tied open.
	Dollar		and blocks off free passage through the	exposure to ambient water quality conditions		due to increased exposure to poor water	At least 1 tidal flap tied open if water temperature < 22 °C.
			of the South Delta			quality and high water temperatures	Sept 15 notch in barrier weirs or flashboard removal Sept 15.
							No agricultural barriers operations after Nov 30.
Delta: South Delta	Transit times	Year round presence	Medium - installation of barriers occurs	Medium - several studies have indicated that the	Reduced survival	Sublethal to lethal:	Ecological surrogates related to barrier operations: (See Section 2.11.1.6.8)
Barriers	Adults - South	(May 1 – November 30)	April/May through the end of November	time through the South Delta and increase		with potential for	May 16 to May31, tidal flaps on culverts tied open.
	Delin.		and blocks off free			increased mortality	

			salvage facilities. Unknown applicability to green sturgeon			Juveniles - Sacramento River -Delta	
9	Increased mortality of entrained fish at the CVP and SWP fish salvage facilities	survival	studies have evaluated the potential risk to salmonids entering the Delta interior and becoming vulnerable to entrainment at the fish	population effects on a small to medium proportion of the population present in the Delta	presence (May 21 – January 30)	entrainment and loss at the South Delta Exports facilities	operations
herbicides, quickly flushed upon radial gate opening coupled with increased exports.		# :					
Radial gates closed at least 24 hours prior to herbicide application, opened 12 to 24 hours after application of copper or endothal based herbicides; no hold time for peroxide based compounds.							
Herbicide concentrations per label restrictions: Copper based ≤1 ppm; endothal based ≤3 ppm; Peroxide based ≤10ppm.	nic ward				greater man 25 C)	River - Delta	
Application of herbicides or mechanical weed harvesting between June 28 and August 31, inclusive, or when water temperatures exceed 25°C.	effects (i.e., reduced growth and survival), due to exposure to harmful compounds in		used. The majority of the studies are on surrogate fish species.		(June 28 – August 31 or when ambient water temperatures are	Adults and juveniles - Sacramento	COLLEGE
Ecological surrogates related to the aquatic weed control program: (See Section 2.11.1.6.7.4)	Sublethal to lethal: adverse physiological	Reduced survival	Medium - several ecotoxicological studies	Medium	Year round presence	Exposure to herbicides	Delta: CCF aquatic weed
No agricultural barriers operations after Nov 30.							
Sept 15 notch in barrier weirs or flashboard removal Sept 15.	temperatures						
At least 1 tidal flap tied open if water temperature < 22°C.	due to increased exposure to poor water quality and high water		exposure to ambient water quality conditions	passage through the three main channels of the South Delta			
Amount or Extent of sDPS Green Sturgeon Take	Type of Incidental Take	Probable Change in Fitness	Weight of Evidence	Magnitude of Effect	Life Stage Timing (Work Window Intersection)	Stressor and Life Stage (location)	Action Component (by division)

Delta: North Bay Aqueduct	Delta: North Bay Aqueduct	Dela North Bay Aqueduct	Delta: North Bay Aqueduct	Action Component (by division)
Impingement/ capture during aquatic weed cleaning Juveniles - Sacramento River -Delta	Entrainment during sediment cleaning Juveniles - Sacramento River -Delta	Routing Juveniles - Sacramento River -Delta	Entrainment and impingement onto fish screens Juveniles - Sacramento River -Delta	Stressor and Life Stage (location)
Year round presence (year round presence)	Year round presence (year round presence)	Year round presence (year round presence)	Year round presence (year round presence)	Life Stage Timing (Work Window Intersection)
Low - fish unlikely to be in area of screens during cleaning	Low - fish unlikely to be in area of screens during cleaning	Low - very small proportion of population will be present in Barker Slough, low impacts of diversion volumes on hydrodynamics	Low - screens are designed for delta smelt criteria, few green sturgeon expected to be present at screen location	Magnitude of Effect
Low – No reports or studies available	Low – No reports or studies available	Low - There is little information regarding green sturgeon migratory movements through the Delta - Green sturgeon juveniles rear within the waters of the Delta for up to 3 years.	High - monitoring has few observations of green sturgeon at this location, multiple studies regarding efficiency of positive barrier fish screens	Weight of Evidence
Minimal change in fitness	Minimal change in fitness	Uncertain, minimal change in fitness	Uncertain, minimal change in fitness	Probable Change in Fitness
Sublethal to lethal: Injury or death due to impingement, capture by grappling hooks during weed removal	Sublethal to lethal: Injury or death due to entrainment into dredge or impingement onto fish screens	Minor: Increased migration times to western Delta	Minor: Injury and Mortality caused by entrainment and/or impingement on the screens at the North Bay Aqueduct, Barker Slough Pumping Plant intake.	Type of Incidental Take
Up to 2 juvenile sDPS green sturgeon per year – take is likely to be lethal	Up to 2 juvenile sDPS green sturgeon per year – take is likely to be lethal	Ecological surrogate related to water diversion rate at Barker Slough Pumping Plant: (See Section 2.11.1.6.2) Diversion of up to 175 cfs	Ecological surrogate related to water diversion rate at Barker Slough Pumping Plant: (See Section 2.11.1.6.2) Diversion of up to 175 cfs	Amount or Extent of sDPS Green Sturgeon Take

Deta Suisun Marsh Roaring Marsh Roaring River Change in water flow/water quality (20 days System Food Subsidy Studies Adults and juveniles may migrate through the area on their way to spawning grounds or as out-migrating juveniles.	Deta: Predator campling gear sampling gear sampling gear Adults and Juveniles - Sacramento River -Delta	Deta: CCWD Rock Slough water diversions Juveniles - Sacramento River -Delta	Action Stressor and Component (by Life Stage division) (location)
SMSCG ops from October through May coincides with the upstream migration of green sturgeon and late winter and spring downstream juvenile migration. During summer ops, juvenile and adult green sturgeon may be present.	Year round presence (January – June)	Year round presence (year round presence)	Life Stage Timing (Work Window Intersection)
Low	Low - infrequent sampling over two to three years of study	Low - small numbers of fish are likely to be in the vicinity of the fish screens and intake	Magnitude of Effect
Low - data on green sturgeon migration and rearing in Suisun Marsh is low	Medium - Several reports from previous predator removal studies, literature on sampling methods.	Low – No reports or studies available regarding green sturgeon presence in front of the fish screens	Weight of Evidence
Minimal	Reduced survival	Minimal change in fimess	Probable Change in Fitness
Minor: During the annual 70 to 80 days of periodic operation, individual adult green sturgeon may be delayed in their spawning migration from a few hours to several days. Green sturgeon are less affected since they spawn in deep turbulent sections of the upper reaches of the Sacramento River.	Sublethal to lethal: Increased vulnerability to injury and predation due to entanglement/entrapm ent in sampling gear	Minor: Delayed migration and increased transit times	Type of Incidental Take
Ecological surrogate based on the SMSCG operations (See Section 2.11.1.6.6) June — September – no more than 60 days of gate closure. Oct-May — no more than 20 days of gate closure. Boat locks are kept open except as needed for boat transit. Gate closures only on flood tides	Over the two-year study Predator Reduction Electrofishing Study: Incidental take of up to 20 adult or juvenile green sturgeon cumulative, with no more than 3 mortalities. Over the two-year Predator Fish Relocation Study: Incidental take of up to 20 adult or juvenile green sturgeon cumulative, with no more than 3 mortalities.	Ecological surrogate related to water diversion rate at Rock Slough Pumping Plant: (See Section 2.11.1.6.4) Diversion of up to 350 cfs	Amount or Extent of sDPS Green Sturgeon Take

Delta Smelt Habitat Action	San Joaquin River PA Conditions	Action Component (by division)
Egg incubation, juvenile rearing	Reductions in spring flows and associated temperatures, water quality, water depth, wetland function. Adults and juveniles San Joaquin River between the confluence with the Stanislaus River and Mossdale	Stressor and Life Stage (location)
Fall-Summer	Adults and juveniles present year round, responses to flow and temperature-related stressors most likely during winter and spring, when the PA has the most limiting effect on flows.	Life Stage Timing (Work Window Intersection)
Variable – Beneficial to Medium	Low	Magnitude of Effect
Low	Low – information available on green sturgeon use of the lower San Joaquin River between Mossdale and the confluence of the Stanislaus River	Weight of Evidence
Variable – Benefits to survival (export reductions) to Reduced Reduced survival due water temperature- related effects	Reduced survival or reduced growth	Probable Change in Fitness
Sublethal to lethal	Sublethal: Decreased survival or growth due to increased exposure to poor water quality and high water temperatures	Type of Incidental Take
Take is exempted to the extent that it is covered under the effects of action components described above (export operations, Salinity Control Gate Operations, Seasonal Operations and other Core Water Operations)	The ecological surrogate is flow, the section of the San Joaquin River from the confluence of the Stanislaus River to Mossdale during adult and juvenile migration. The extent of incidental take is that associated with implementation of the SRP minimum flows (as revised by the Stanislaus Watershed Team). Extent of incidental take is all adults and juveniles exposed to the stressors throughout this section of the San Joaquin River from the confluence of the Stanislaus River to Mossdale due to inhibited migration from reduced flows.	Amount or Extent of sDPS Green Sturgeon Take

If the ecological surrogates from the above tables are not met and maintained, Reclamation and DWR will be considered to have exceeded their anticipated incidental take levels, thus requiring Reclamation and DWR to coordinate with NMFS within 24 hours, to discuss ways to reduce the amount of incidental take back to anticipated levels.

2.11.1.5 Operation of CVP and SWP Dams and Reservoirs

The following section provides further description of the adverse effects of the PA, resulting in varying forms of incidental take. For some PA components and ecological surrogates identified in the tables above, further discussion is warranted, and is included below.

2.11.1.5.1 Water Temperatures and Flows in Clear Creek, and the American River, and Flows in the Sacramento and Stanislaus Rivers

The following section provides a summary list of incidental take identified in the tables above due to project operations.

Operations of the CVP and SWP reservoirs result in incidental take, including:

- dewatering a portion of Sacramento River winter-run, CV spring-run, and CCV steelhead redds, resulting in egg and pre-emergent fry mortality;
- poor development of sDPS green sturgeon embryos and larvae when water temperatures exceed suitable levels in the lower reaches of spawning habitat;
- mortality of juvenile CCV steelhead resulting from high water temperatures (e.g., Clear Creek, American River, Stanislaus River, San Joaquin River);
- limited availability and suitability of habitat for juvenile rearing and emigrating winterrun Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead;
- creation of thermal barriers during adult salmonid migration that block or delay access to holding and spawning habitat, increasing risk of mortality due to exposure to suboptimal water temperatures, predation, and poaching; and
- restricted window of successful outmigration and thus reduced diversity of outmigration timing for CV spring-run and CCV steelhead populations on the Stanislaus River.

2.11.1.5.1.1 Incidental Take due to Water Temperatures in the Stanislaus and San Joaquin Rivers

The ecological surrogate to define the extent of water temperature-related incidental take in the Stanislaus River is the reach from Goodwin Dam to Orange Blossom Bridge (OBB) during times when rearing juvenile CCV steelhead experience suboptimal water temperatures. The extent of water temperature-related incidental take in the San Joaquin River is the reach from the confluence of the Stanislaus River, downstream to Mossdale when juvenile CCV steelhead rear and emigrate. Incidental take in the form of harm to juvenile CCV steelhead is expected, as a result of PA operations. Suboptimal water temperatures are expected to result in reduced survival during the juvenile life stage.

Incidental take is exceeded if the monthly average of measured average daily water temperature exceeds the 75th percentile of modeled monthly average temperature at OBB (for Stanislaus

River) and at VER (for San Joaquin River, see Table 2.11.1-1), unless the measured 7DADM water temperatures are less than the EPA criteria for that particular life stage (see Table 2.5.7-11 in the Effects of the Action section). Incidental take is limited to monthly temperature exceedances no more than once every four years, for each month. Temperature exceedances are likely to occur more frequently during critically dry years, particularly in May and June.

Table 2.11.1-5. Table showing OBB and VER 75th Percentile Temperatures (in degrees F) Modeled CALSIM II Temperatures by Month.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Stanislaus (OBB)	50	52	55	55	58	64	66	65	63	58	56	52
Lower San Joaquin (VER)	50	55	61	65	69	76	79	77	74	65	57	50

2.11.1.5.3 Downstream Sacramento River Temperatures due to Shasta Reservoir Operations

The following section includes additional description of the ecological surrogates defined in the tables above, used to define the amount or extent of temperature related take due to Shasta Reservoir operations.

The quantitative modeling of effects that are available are limited to the winter-run Chinook species, and they do not accurately describe the PA. Specific to Shasta temperature management, the following limitations on the available quantitative models make a quantification of take difficult:

- CalSimII modeling, reviewed for the opinion, does not include all components of the PA
 as described in the June 14, 2019, final PA.
- HEC-5Q modeling (which relies on the CalSimII modeling output) reviewed for the opinion does not include all elements of the PA described in the June 14, 2019, final PA. Specifically:
 - Start and end date/time of temperature management is more variable under the final PA than what is described by modeling (timing and location of redds being less variable).
 - Temperature operations and TCD shutter configuration for Tiers 2 and 3 of summer cold water pool management is not adequately reflected in the modeling due to model limitations.
 - Operational (i.e., temperature) target in Tier 4 of summer cold water pool
 management is unclear; this affects interpretation of results and whether they
 describe effects of the PA in Tier 4.
- Temperature Dependent Mortality results (which are based on the CalSimII and HEC-5Q modeling outputs) are limited to winter-run Chinook salmon and unavailable for CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon.

Instead of a strict quantitative value of take, the ecological surrogate for harm related to Shasta water operations is based on a measure of available habitat for spawning and egg/alevin incubation. The extent of habitat available considered in this opinion is based on annual operations and the following criteria:

- Adherence to an annual Shasta Cold Water Management Plan that defines operations
 within a temperature management tier. The annual Shasta Cold Water Management Plan
 is a surrogate for available habitat because the plan provides an estimate of achievable
 conditions in the river during the year.
 - o If Reclamation makes a significant deviation from the plan in a way that would reduce the availability of habitat (i.e., higher temperatures, or shorter duration of suitable temperatures) (i.e., more than 5 consecutive days above the allowable tolerances identified in the plan) or if Reclamation shifts to a warmer tier of *Summer Cold Water Pool Management* for reasons other than emergencies as identified in the PA, then the ecological surrogate will have been exceeded if NMFS also deems that Reclamation's operations were not consistent with the Shasta specific performance metrics identified in the final PA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics).
- Consistency with operational performance metrics described in BA Section 4.10.1.3.3 (Upper Sacramento Performance Metrics) and/or the Drought and Dry Year Actions. Reclamation proposes a number of performance metrics aimed at assessing whether the range of effects associated with the Summer Cold Water Pool Management component of the PA are within the range of effects considered. The performance metrics also include provisions for chartering an independent panel consistent with "Chartering of Independent Panels" under the "Governance" section of the PA if recommended by the SRTTG after identifying that a metric is not met. The performance metrics offer an opportunity to collectively assess the effect of operations and whether those effects were adequately considered without triggering reinitiation of consultation.
- In the event of two consecutive years of poor winter-run Chinook salmon egg-to-fry survival, below 15 percent, measures must be taken to achieve egg-to-fry survival of at least 15 percent for the third year, including those measures outlined in the final PA Section 4.10.1.4.2 (Conservation Measures). If egg-to-fry survival appears to be on track to meet 15 percent or better during the third year, then Reclamation may proceed with operations pursuant to the PA. However, if egg-to-fry survival is projected to be less than 15 percent during the third year, then reinitiation of consultation would be likely.

2.11.1.6 Operations in the Delta

The following section includes additional description of the ecological surrogates defined in the tables above, used to define the amount or extent of incidental take occurring in the Delta as a result of the PA.

Incidental take in the form of death, injury, and harm to juvenile and adult Sacramento River winter-run and CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon is anticipated due to the implementation of the PA components, including the operations of the DCC gates, the BSPP and NBA, the CCWD Rock Slough diversion, the Suisun Marsh Salinity Control Gates, the south Delta agricultural barriers, and the CVP and SWP export facilities in the south Delta. In most cases, the quantification of incidental take will not be possible, and NMFS must use ecological surrogates as a proxy for take.

2.11.1.6.1 DCC Gate Operations

Because it is nearly impossible to detect unmarked (i.e., not carrying acoustic tag or other similar detectable device), listed fish entering the mouth of the DCC when the gates are open, an ecological surrogate will be used to establish criteria for incidental take caused by the operations of the DCC radial gates. While individual fish will be present in the action area surrounding the junction of the Sacramento River with the DCC, NMFS cannot, using the best available information, precisely quantify and track the amount or number of individuals that are expected to be incidentally taken (injured, harmed, killed, etc.) per species as a result of the proposed action component related to the operations of the DCC. This is due to the variability and uncertainty associated with the response of listed species to the effects of the proposed action, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing injured or dead fish lost to the Delta interior route. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates those elements of the PA that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring.

Observations of listed salmonids, both natural and hatchery, entering the DCC route when the gates are open are nearly impossible to achieve. Turbidity in the Sacramento River is frequently a limiting factor in visually observing listed salmonids or sDPS green sturgeon. The clarity of the river water limits visual detection to typically a few feet below the surface, leaving most of the water column obscured from the observer. Acoustic imaging is possible but not practicable, as the targets (acoustic images) frequently lack the details to determine species level determination, and can be obscured by debris and air bubbles in the water, both of which reflect the acoustic beam. Deployment and maintenance of the equipment requires considerable effort. However, as mentioned previously, the routing of fish into the DCC only occurs when the DCC gates are open. Therefore, the position of the gates is an informative indicator of the potential incidental take of listed fish due to routing into the DCC waterway and subsequently into the Delta interior where loss occurs. When the gates are open, fish can be routed into the interior Delta through the DCC and hydrodynamics downstream of the DCC junction are negatively impacted; when the gates are closed fish are not routed through the DCC into the Delta interior and hydrodynamics below the junction continue to function in a normal way. The incidental take of listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon, is associated with the operations the gate, and the operational schedule proposed for the gates will represent the ecological surrogate for take. The most appropriate threshold for incidental take is an ecological surrogate of habitat alteration caused by the opening of the radial gates of the DCC that allows Sacramento River water to flow into the DCC and thence into the Delta interior waterways of Snodgrass Slough and the Mokelumne River system. This flow of water away from the Sacramento River and into the Delta interior facilitates the diversion of listed fish into the waterways of the interior Delta where survival has been shown to be considerably less than the migratory routes associated with the Sacramento River.

Ecological Surrogate:

Incidental take is limited to the gate operations pursuant to the June 14, 2019, final PA.

2.11.1.6.2 North Bay Aqueduct / Barker Slough Pumping Plant

Since the ability to detect listed fish presence in Barker Slough prior to encountering the fish screen in front of the Barker Slough Pumping Plant (BSPP) is nearly impossible, an ecological surrogate will be used to establish criteria for incidental take of the operations of the North Bay Aqueduct (NBA)/ BSPP. While individual fish may be present in the waterway leading up to the fish Screen, NMFS cannot, using the best available information, precisely quantify and track the amount or number of individuals that are expected to be incidentally taken (injured, harmed, killed, etc.) per species as a result of the proposed action component related to the operations of the NBA/BSPP. This is due to the variability and uncertainty associated with the response of listed species to the effects of the proposed action, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing injured or dead fish lost within the waterways leading to the BSPP. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates, those elements of the PA that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring.

The most appropriate threshold for incidental take is an ecological surrogate of habitat alteration caused by the diversion of water through the BSPP that allows Delta water to flow towards the facility, and potentially causing alterations in fish behavior, such as migratory delays, and increasing the vulnerability of such fish to increased predation through increased exposure time in Barker Slough. Therefore, the ecological surrogate for incidental take of listed winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon will be the maximum diversion rate of 175 cfs.

2.11.1.6.3 Incidental Take for North Bay Aqueduct / Barker Slough Pumping Plant Sediment and Weed Control Operations:

The removal of sediment that accumulates in front of the screens and within the pumping bays of the BSPP will pose a risk of entrainment. If dredging is used to remove sediment buildup on the aprons in front of the fish screens, there is the potential for incidental take as fish may be entrained into a hydraulic dredge while the sediment is removed. However, since the volume of sediment removed is relatively small compared to many dredging operations, the dredge effluent can be readily observed for the presence of listed unclipped salmonids or sDPS green sturgeon in the sediment containment ponds into which the dredge spoils are discharged. NMFS will set an incidental take limit of 5 unclipped listed salmonids (cumulative) per year, including the potential for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, to be entrained each year through the use of hydraulic dredging methods in front of the fish screens. The incidental take limit for sDPS green sturgeon will be 2 fish per year.

The removal of vegetation that accumulates on the BSPP fish screens has the potential to result in incidental take of listed salmonids and sDPS green sturgeon, as described in the effects section. NMFS will set an incidental take limit of 5 unclipped juvenile listed salmonids (cumulative) per year, including the potential for winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, to be entrapped each year through the use of the aquatic weed removal methods. The incidental take limit for sDPS green sturgeon will be 2 juvenile fish per year.

Table 2.11.1-6. Incidental Take for Sediment Removal and Aquatic Weed Control

Action	Cumulative Take of Juvenile Salmonids (WR, SH, SR,) Individuals/year	Cumulative Take of Juvenile SDPS Green Sturgeon/ year
Sediment Removal	5	2
Weed Removal	5	2

2.11.1.6.4 Contra Costa Water District – Rock Slough Water Diversion Operations

Since the ability to detect listed fish presence in Rock Slough prior to encountering the fish screen in front of the Rock Slough Head Works is nearly impossible, an ecological surrogate will be used to establish criteria for incidental take of the operations of the Contra Costa Water District (CCWD) Rock Slough Intake. While individual fish may be present in the waterway leading up to the fish screen, NMFS cannot, using the best available information, precisely quantify and track the amount or number of individuals that are expected to be incidentally taken (injured, harmed, killed, etc.) per species as a result of the proposed action component related to the operations of the CCWD Rock Slough Intake. This is due to the variability and uncertainty associated with the response of listed species to the effects of the proposed action, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing injured or dead fish lost within the waterways leading to the CCWD Rock Slough Intake. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates, those elements of the PA that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring.

The most appropriate threshold for incidental take, is an ecological surrogate of habitat alteration caused by the diversion of water through the Rock Slough Intake's fish screens that allows Delta water to flow towards the facility, and potentially causing alterations in fish behavior, such as migratory delays, and increasing the vulnerability of such fish to increased predation through increased exposure time in Rock Slough. The maximum rate of diversion currently permitted is 350 cfs, and is the upper limit of diversion that NMFS assessed in its effects analysis for the CCWD Rock Slough Intake operations in the PA for migratory delays. Therefore, the ecological surrogate for incidental take of listed winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS will be the maximum permitted diversion rate of 350 cfs. If diversion of water through the CCWD Rock Slough intake exceeds this rate, then incidental take of listed salmonids and sDPS green sturgeon will have been exceeded.

2.11.1.6.5 Water Transfers

NMFS anticipates that incidental take of listed salmonids and sDPS green sturgeon upstream of the Delta related to the transfer of water from upstream locations to downstream facilities will be minimal, but some individual fish may be lost due to stranding in side channels or pools as water flows decrease after the completion of the transfer and water recedes from inundated shoreline habitat. Stranding surveys are conducted after flow reductions to scout for locations of stranding, but due to the difficulty in quickly identifying stranding locations, and then quantifying the

number of individuals in each stranding location, the results of the surveys are not exact as to the number of fish affected. Stranded fish are captured by seining the side channels and pools, data collected as to the number rescued, species, body length, and potential run classification, and returned to the river as quickly as possible. However, this is a crude assessment of the total number of fish stranded, as not all potential stranding locations are identified, and some fish may be lost to predation prior to being rescued by terrestrial or avian predators, and thus never enumerated. Since the ability to detect the location and spatial distribution of individual listed fish presence in Central Valley waterways is not always possible, NMFS cannot, using the best available information, precisely quantify and track the amount or number of individuals that are expected to be incidentally taken (injured, harmed, killed, etc.) per species as a result of the proposed action component related to the transfer of upstream water to downstream facilities. This is due to the variability and uncertainty associated with the response of listed species to the effects of the proposed action, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing injured or dead fish lost within the waterways of the Central Valley containing listed salmonids and sDPS green sturgeon. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates, those elements of the PA that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring.

The most appropriate threshold for incidental take is an ecological surrogate of habitat alteration (riparian and shoreline habitat inundation) caused by the seasonal timing and volume of water released during the transfers.

Incidental take of listed salmonids and sDPS green sturgeon related to the export of the transfer water under this component of the PA will be included under the incidental take limits for the operations of the south Delta export facilities of the SWP and CVP.

Ecological Surrogates:

Permitted season of water transfers – July 1 – November 30.

Permitted Volumes of transfers:

Table 2.11.1-7. Permitted Volumes of Transfer Water

Water year type	Maximum Transfer Amount (TAF)
Critical	Up to 600
Dry (following Critical)	Up to 600
Dry (following Dry)	Up to 600
All other Years	Up to 360

2.11.1.6.6 Suisun Marsh Salinity Control Gate Operations

Since the ability to detect listed fish presence in Montezuma Slough prior to encountering the Suisun Marsh Salinity Control Gates (SMSCG) is nearly impossible during the proposed periods of closure, an ecological surrogate will be used to establish criteria for the incidental take of listed salmonids and sDPS green sturgeon during the operations of the SMSCG. While individual

fish may be present in the waterway leading up to the gates during periods of closure, NMFS cannot, using the best available information, precisely quantify and track the amount or number of individuals that are expected to be incidentally taken (injured, harmed, killed, etc.) per species as a result of the proposed action component related to the operations of the SMSCG. This is due to the variability and uncertainty associated with the response of listed species to the effects of the proposed action, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing delayed, injured, or dead fish lost within the waterways leading to the SMSCG. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates, those elements of the PA that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring.

The most appropriate threshold for incidental take, is an ecological surrogate of habitat alteration caused by the closure of the radial gates during flood tides within the periods of operations of the SMSCG, and potentially causing alterations in fish behavior, such as migratory delays, and increasing the vulnerability of such fish to increased predation through increased exposure time in the channel of Montezuma Slough adjacent to the radial gates.

Ecological Surrogates:

 Incidental take is limited to the operation of the SMSCG pursuant to the June 14, 2019, final PA.

2.11.1.6.7 South Delta Export Operations

2.11.1.6.7.1 CVP and SWP Salvage and Loss Incidental Take

NMFS and Reclamation held technical discussions in May 2019 and have developed a set of loss thresholds for natural winter-run Chinook salmon and natural CCV steelhead as Delta performance metrics in the final PA provided on June 14, 2019. Performance targets/loss thresholds provide for review by an independent panel, but do not represent an incidental take limit. The calculations underlying these loss thresholds utilize the loss data from water years 2010 through 2018 for salmonids. The loss thresholds were calculated as 90 percent of the maximum annual historical loss (for salmonids) based on the period between 2010 and 2018. Length at date criteria are used for run designation in the data for Chinook salmon loss.

2.11.1.6.7.1.1 Winter-run Chinook salmon

The cumulative annual loss limit for natural winter-run is 1.6 percent of the JPE [the maximum loss for the period from 2010 to 2018 of 1.30 percent of the JPE, plus a 20 percent allowance to provide a buffer for an occasional higher loss year.

Table 2.11.1-8. Natural winter-run loss for the period of December through March (Loss expressed both as percentage of 2 percent of JPE and as a percentage of the JPE).

WATER YEAR	CUMULATIVE LOSS OF UNCLIPPED WR-SIZED CHINOOK as % of 2% of WR JPE	
2010	6.8	
2011	64.8	
2012	59.3	
2013	6.7	
2014	1.3	
2015	4.3	
2016	2.8	
2017	2.0	
2018	13.8	
	% of 2% of WR JPE	% of WR JPE
Average Dec-March cumulative loss	18.0	0.36
Maximum Dec-March cumulative loss	64.8	1.30
90% of maximum historical loss	58.3	1.17
50% of 90% of maximum historical loss	29.2	0.58
75% of 90% of maximum historical loss	43.7	0.87

The annual incidental take limit for hatchery produced winter-run Chinook salmon from LSNFH released into the upper Sacramento River will be 0.8 percent per year of the estimated hatchery JPE (fish surviving to the Delta) for this specific release location, which is provided in the annual NMFS JPE letter. Similarly, the annual incidental take limit for hatchery produced winter-run Chinook salmon that are released into Battle Creek as part of the reintroduction program will be 0.8 percent per year of the estimated hatchery JPE for this specific release location, which is provided in the annual NMFS JPE letter.

2.11.1.6.7.1.2 CV Spring-run Chinook salmon

The annual incidental take limit for natural yearling CV spring-run Chinook salmon emigrating from the tributaries to the Sacramento River is based on an ecological surrogate of hatchery releases of late fall-run Chinook salmon from the CNFH released into Battle Creek. The incidental take limit will be 1 percent of the number of fish released in each surrogate release group.

Designation of run by LAD is not sufficiently accurate to determine the exact number of CV spring-run juveniles taken due to the high overlap in sizes with co-occurring fall-run Chinook salmon. However, the take of juvenile spring-run sized fish by LAD is monitored and reported out by the CVP and SWP fish facilities. The annual incidental take limit for natural young-of-year CV spring-run Chinook salmon emigrating from the tributaries to the Sacramento River is based on an ecological surrogate of OMR Management pursuant to the June 14, 2019, final PA. Furthermore, in determining the extent of incidental take of spring-run Chinook salmon,

Reclamation will consider the information in the technical memorandum developed annually by NMFS to ensure that take of Central Valley spring-run Chinook salmon originating from reintroduction to the San Joaquin River is deducted from the incidental take calculation to ensure that the reintroduction does not cause more than a *de minimus* impact on water supply, additional storage releases, and bypass flows associated with the operations of the CVP and SWP as described in 50 CFR 223.301(b)(5)(ii)(B).

2.11.1.6.7.1.3 CCV Steelhead

The cumulative annual loss limit for natural CCV steelhead from December to March is 1,885 [the maximum loss of 1,571 for the period between 2010 and 2018, plus a 20 percent (314 CCV steelhead) allowance to provide a buffer for an occasional higher loss year].

The cumulative annual loss limit for natural CCV steelhead from April to June 15 is 2,070 [the maximum loss of 1,725 for the period of 2010 to 2018, plus a 20 percent (345 CCV steelhead) allowance to provide a buffer for an occasional higher loss year].

Table 2.11.1-9. Natural steelhead loss for the period of December through March, and April through June 15.

	Cumulative loss of unclipped steelhe				
Water Year	Dec-Mar	Apr-Jun 15			
2010	1571.15	382			
2011	929.7	1419.13			
2012	740.56	371.81			
2013	1013.88	1197.2			
2014	201.69	58.82			
2015	77.94	61.73			
2016	245.92	46.7			
2017	60.12	113.69			
2018	1127.01	1724.64			
average	663	597			
max	1571	1725			
90% of max	1414	1552			
75% of 90% of max	1061	1164			
50% of 90% of max	707	776			

2.11.1.6.7.1.4 sDPS Green Sturgeon

There is no known population estimate for sDPS green sturgeon in order to determine an appropriate level of incidental take and recent salvage has been very low. The incidental take limit is based on the historical salvage considered in the NMFS 2009 opinion and sDPS green sturgeon (expanded) salvage is not expected to exceed 74 juveniles per year.

2.11.1.6.7.2 Predator Reduction Electrofishing Study (PRES)

Based on results of previous years of studies, the cumulative two-year incidental take limit for the Predator Reduction Electrofishing Study will be as follows:

Table 2.11.1-10. Cumulative Incidental Take for PRES

Species	Cumulative Incidental Take (juveniles and adults)	Lethal Take as Part of Cumulative Incidental Take (juveniles and adults)
sDPS Green Sturgeon	20	3
CCV steelhead (unclipped)	50	5
CV spring-run Chinook salmon	50	5
Winter-run Chinook salmon	50	5

- No electrofishing will occur if water temperatures in CCF are greater than 21°C.
- Electrofishing may occur in CCF between January 1st and June 30th as conditions allow.
- Incidental take for the PRES does not count towards the incidental take of the SWP and CVP fish salvage facilities.

Incidental take will be in the form of harassment, capture, handling, and potentially mortality, occurring during processing.

2.11.1.6.7.3 Predatory Fish Relocation Study (PFRS)

Based on previous years of studies with the Predator Reduction Electrofishing Study, the cumulative two-year incidental take limit for the Predatory Fish Relocation Study (PFRS) will be as follows:

Table 2.11.1-11. Cumulative Incidental take for the PFRS

Species	Cumulative Incidental Take (juveniles and adults)	Lethal Take as Part of Cumulative Incidental Take (juveniles and adults)
sDPS Green Sturgeon	20	3
CCV steelhead (unclipped)	50	5
CV spring-run Chinook salmon	50	5
Winter-run Chinook salmon	50	5

- Fish collection methods will be limited to the following types of fishing gear:
 - Beach seine
 - Purse seine
 - Fyke trap

- Hoop trap
- o Trawl net with skids
- The PFRS will be conducted between January 1st and June 30th as conditions allow.
- No fish collection efforts will occur once water temperatures in CCF exceed 21°C.
- Incidental take for the PFRS does not count towards the incidental take of the SWP and CVP fish salvage facilities or the PRES.

Incidental take will be in the form of harassment, capture, trap, handling, and potentially mortality, occurring during processing.

2.11.1.6.7.4 Aquatic Weed Control and Algal Bloom Management in Clifton Court Forebay

Since the ability to detect listed fish presence in CCF prior to application of the proposed herbicides or the use of the mechanical harvester is based on the observation of fish in salvage at the SDFPF, these observations do not allow any precise quantification of the number of fish actually present in CCF at the time of herbicide application or use of the mechanical harvester that may be incidentally taken as a result of the action. Therefore, an ecological surrogate will be used to establish criteria for the incidental take of listed salmonids and sDPS green sturgeon during the implementation of the CCF aquatic weed and algal bloom management program. While individual fish may be present in the CCF during periods of herbicide applications or use of the mechanical harvester, NMFS cannot, using the best available information, precisely quantify and track the amount or number of individuals that are expected to be incidentally taken (injured, harmed, killed, etc.) per species as a result of actions related to the CCF aquatic weed and algal bloom management program. This is due to the variability and uncertainty associated with the response of listed species to the effects of the proposed action, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing physiologically distressed, injured, or dead fish lost within the CCF during the aquatic weed and algal bloom management action. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates, those elements of the PA that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring.

The most appropriate threshold for incidental take, is an ecological surrogate of habitat alteration caused by the start date of the application of herbicides to CCF in conjunction with other operational parameters such as the concentration of herbicide in the water column, water temperature in CCF, and the operational status of the radial gates leading into CCF.

Ecological surrogates:

Herbicides utilized in the aquatic weed and algal bloom management, applied at concentrations per EPA registration label restrictions:

- Aquathol K (or other dipotassium salts of endothal based herbicide) 2-3 parts per million (ppm) target concentration.
- Chelated copper based herbicides (copper-ethylenediamine complex and copper sulfate pentahydrate, copper carbonate compounds, or other copper-based herbicides); 1 ppm

target concentration for aquatic weeds; 200 parts per billion (ppb) to 1 ppm for algal control.

- peroxygen-based algaecides (e.g. PAK 27); 300 ppb to 10.2 ppm as hydrogen peroxide targeted concentration.
- Incidental take will be exceeded if application of herbicides or use of the mechanical harvester is done earlier than June 28th or later than August 31st, and the water temperatures are less than 25°C. The exception to this is if NMFS concurs with DWR's request to apply herbicides or use the mechanical harvester outside the application window due to water temperatures being greater than 25°C. Incidental take will also be exceeded if the concentrations of herbicides applied to CCF exceed the described target concentrations. Furthermore, if the radial gates are not closed at least 24 hours prior to applications of herbicides with the concurrent draw down of CCF water elevation, and reopened less than 12 hours afterwards for endothal or copper based herbicides, then incidental take has been exceeded. The radial gates may be opened immediately after application of peroxide-based algaecides. Finally, incidental take will be exceeded if more than 50 percent of the surface area of CCF is treated at any one time during herbicide applications.

2.11.1.6.8 South Delta Temporary Agricultural Barriers

Since it is impossible to quantify with any precision the number of listed fish present in the channels of Old River, Middle River, and Grantline Canal during installation of the three temporary agricultural barriers and the barriers' subsequent operations, an ecological surrogate will be used to establish criteria for the incidental take of listed salmonids and sDPS green sturgeon during the periods when the temporary agricultural barriers are in place. While individual fish may be present in the waterway leading up to the barriers during periods of installation and closure, NMFS cannot, using the best available information, precisely quantify and track the amount or number of individuals that are expected to be incidentally taken (injured, harmed, killed, etc.) per species as a result of the proposed action component related to the operations of the barriers. This is due to the variability and uncertainty associated with the response of listed species to the effects of the PA, the varying population size of each species, annual variations in the timing of spawning and migration, individual habitat use within the action area, and difficulty in observing delayed, injured, or dead fish lost within the waterways adjacent to the three temporary agricultural barriers. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates, those elements of the PA that are expected to result in incidental take, that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that is occurring.

The most appropriate threshold for incidental take is an ecological surrogate of habitat alteration caused by the closure of the channels by the installation of the barriers and extending through the periods of operations of the barriers. This alteration in the functioning of the channel habitat may potentially cause changes in fish behavior, such as migratory delays, and increases the vulnerability of such fish to predation through increased exposure time to predators residing in waters adjacent to the temporary agricultural barriers. NMFS has described which aspects of the south Delta temporary agricultural barriers will cause incidental take to occur.

Incidental take will be exceeded if:

- The operation of the barriers occurs earlier than May 1st, or if the barriers are not removed by November 30th of each year.
- Culverts are installed and operated in such a way as to preclude passage of fish from May 16th to May 30th if DWR has not clearly demonstrated a water elevation situation that would require their closure.
- If water temperatures are below 22°C, and all of the tidal flap gates are operational at each barrier location without at least one tidal flap at each barrier being tied open to allow fish passage.
- By September 15th of each year, a notch has not been cut in the weir of Old River at Tracy and Middle River barriers, and the appropriate number of flashboards removed at Grant Line Canal barrier to facilitate upstream movement of Chinook salmon.

2.11.1.7 Southern Resident Killer Whales

NMFS anticipates the PA will result in incidental take in the form of harm to SRKW individuals through impairment of foraging behavior through reduced productivity for all Central Valley Chinook salmon populations, including fall-run Chinook salmon, resulting from the adverse effects for Chinook salmon described in Tables 2.11.1-1 through 2.11.1-4 above and summarized in Section 2.5.8 Southern Resident Killer Whale Effects Analysis. NMFS anticipates that this reduction in the productivity and abundance of Central Valley Chinook salmon will result in some level of harm to SRKWs, specifically members of K and L pod (currently 52 individuals), by reducing prey availability and causing impairment in foraging behavior, leading animals to forage for longer periods, travel to alternate locations, and experience nutritional stress and related health effects. These adverse effects increase the probability that SRKW individuals would be subject to reduced survival and reproductive success over time.

Currently, we cannot readily observe or quantify impacts to foraging behavior or any changes to health of individual killer whales in the population from the general level of prey reduction that has been described in the proposed action because we do not have the data or metrics needed to monitor and establish relationships between the effects of the PA and individual SRKW health. As a result, we will rely on surrogates of the amount or extent of incidental take of SRKWs as a result of the PA in the form of the extent of effects to Chinook salmon populations relevant to the effects analysis described in Sections 2.5.8 Southern Resident Killer Whale Effects Analysis and 2.7.10 Integration and Synthesis for Southern Resident Killer Whales. Specifically, we will rely upon ecological surrogates that are used to describe and monitor the take of ESA-listed salmonids resulting from adverse effects of the proposed action.

In Section 2.11.1.5 Operation of CVP and SWP Dams and Reservoirs, measures of ecological surrogates are used for describing anticipated temperature-and-flow related effects that diminish the productivity of all Central Valley Chinook populations. Exceedance of the extent of effects as measured by any of these ecological surrogates for effects to Chinook salmon would be viewed as an exceedance of the anticipated harm to SRKWs. In Section 2.11.1.6 Operations in the Delta, measures of ecological surrogates are used for describing anticipated effects that diminish productivity of all Central Valley Chinook salmon from a number of activities, including the operations of the DCC gates, the BSPP and NBA, the CCWD Rock Slough diversion, the Suisun Marsh Salinity Control Gates, and the south Delta agricultural barriers.

Exceedance of the extent of effects as measured by any of these ecological surrogates for effects to Central Valley Chinook salmon would be viewed as an exceedance of the anticipated harm to SRKWs. In Section 2.11.1.6.7 South Delta Export Operations, loss thresholds for natural winterrun Chinook salmon and natural CCV steelhead used as surrogates for incidental take of these ESA-listed species resulting from operation of CVP and SWP export facilities in the south Delta are described. In addition, an ecological surrogate loss threshold for CV spring-run (based on late fall-run Chinook salmon from the CNFH released into Battle Creek) is described. In the absence of a loss threshold specifically for non-listed Central Valley fall-run Chinook salmon populations, or for all Central Valley Chinook salmon, exceedance of the extent of effects as measured by any of the loss threshold surrogates for effects to any Central Valley Chinook salmon would be viewed as an exceedance of the anticipated harm to SRKWs. In addition, because the loss threshold based on the performance measures developed for natural CCV steelhead is expected to benefit Central Valley fall-run Chinook salmon populations by minimizing export impacts on Central Valley fall-run Chinook salmon during their migration through the south Delta, exceedance of this threshold would also be viewed as an exceedance of the anticipated harm to SRKWs.

2.11.2 Effect of the Take

In the Opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the PA, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat when the reasonable and prudent alternative is implemented. In the accompanying formal biological opinion, NMFS has determined that the anticipated level of incidental take associated with the PA, as modified by the RPA, is not likely to jeopardize the continued existence of winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon, and SRKWs.

2.11.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize take of winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, sDPS green sturgeon and SRKWs.

- Reclamation and DWR shall minimize incidental take of listed species during operations
 of the Shasta Division.
- Reclamation and DWR shall minimize incidental take of listed species during operations in Clear Creek.
- Reclamation and DWR shall minimize incidental take of listed species during operations of the American Division.
- Reclamation and DWR shall minimize incidental take of listed species during operations
 of the Eastside Division.

- Reclamation and DWR shall minimize incidental take of listed species during operations of the Bay-Delta Division.
- Reclamation and DWR shall minimize incidental take of Southern Resident killer whales during operations.
- 7. Reclamation and DWR shall monitor the amount and extent of incidental take described in Section 2.1 as necessary to implement this Opinion.
- 8. Reclamation shall minimize the incidental take of listed species associated by implementation of the proposed action by supporting the implementation of actions through the Collaborative Planning action component.
- 9. Sacramento River Settlement Contractor measures.
- 10. Reclamation and DWR shall coordinate with together and with NMFS to minimize incidental take of listed species related to coordinated operations.

2.11.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Reclamation and DWR must comply with them in order to implement the RPMs (50 CFR 402.14). Reclamation and DWR have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse. Reclamation and DWR must comply or ensure compliance by their contractor(s) with the following terms and conditions, which implement the reasonable and prudent measures described above.

NMFS requests that by June 17, 2020, Reclamation provide written notification to NMFS and the State Water Resources Control Board (SWRCB) of any contract that it believes creates a nondiscretionary obligation to deliver water, including the basis for this determination and the quantity of nondiscretionary water delivery required by the contract.

For the purposes of this Opinion, NMFS "coordination" with Reclamation and DWR does not mean NMFS concurrence with an action is required under the specified coordination, but rather that NMFS is afforded the opportunity to provide scientific or technical recommendations for Reclamation's consideration on issues for which NMFS has scientific or technical expertise, such as biological issues. Such recommendations would not require changes to Reclamation's Proposed Action, or water and power resources operations and facilities operations pursuant to the Proposed Action.

11. RPM 1: Reclamation and DWR shall minimize incidental take of listed species during operations of the Shasta Division.

- a. To minimize the adverse effects of flow fluctuations on listed anadromous fish species spawning, incubation, and juvenile rearing, Reclamation shall implement the following ramping rates. During periods outside of flood control operations and to the extent controllable during flood control operations, Reclamation shall ramp down releases in the Sacramento River below Keswick Dam from July 1 through March 31 as follows, except as discussed with the SRTTG, including providing an opportunity for technical assistance by NMFS, and for the purposes of providing fish pulse flows that deviate from these levels, or conserving the cold water pool:
 - i. Releases must be reduced between sunset and sunrise;
 - ii. When Keswick releases are 6,000 cfs or greater, decreases may not exceed 15 percent per night. Decreases also may not exceed 2.5 percent in one hour;
 - iii. Foe Keswick releases between 4,000 and 5,999 cfs, decreases may not exceed 200 cfs per night. Decreases also may not exceed 100 cfs per hour;
 - iv. For Keswick releases between 3,250 and 3,999 cfs, decreases may not exceed 100 cfs per night.
 - v. Variances to these release requirements are allowed under flood control operations.
- b. Reclamation and DWR shall coordinate with NMFS about forecasted Shasta operations starting with the February forecast, through the April forecast.
- c. In coordination with NMFS and the SRTTG, Reclamation shall consider technical assistance from NMFS regarding the development of annual temperature management plans, regardless of Shasta storage or tiered temperature management stratum. Reclamation shall submit the final temperature management plan to NMFS by May 20 of each year, as reporting under the opinion. NMFS does not expect Reclamation to seek NMFS concurrence on the plan.

In February of each year Reclamation shall create and post a projection of water operations, as described in Appendix C of the BA. In addition, this projection shall include the following:

- i. An assessment of the performance to date of Shasta Cold Water Pool Management based on expectations outlined in the final PA, Section 4.10.1.3.3 (Upper Sacramento Performance Metrics), which includes:
 - (a) Performance trends to date, frequency of Tiers, range of TDM within Tiers, and range of egg to fry survival within Tiers,
 - (b) Whether convening an independent panel is appropriate based on performance trends to date, and
 - (c) Response to previous independent panel reviews and/or identification of how comments from previous independent panel(s) are being addressed.
- ii. A forecast of likely Shasta Cold Water Pool Management Tier and whether Reclamation is proposing to implement the "Anderson approach" to target critical periods in egg and alevin development.
- d. Reclamation shall implement the Spring Pulse Flow as described in its February 5, 2019, BA. The Spring Pulse Flow, as modified in subsequent PAs (April 30, 2019, revised PA, and June 14, 2019, final PA) was not analyzed, discussed, nor agreed upon during

- multiple consultation meetings between Reclamation and NMFS, nor flagged during Reclamation's multiple review of NMFS' Shasta Division effects analysis.
- e. Consistent with the final PA, Reclamation shall develop a stratification model for Shasta Reservoir and evaluate this model for implemention as part of the development of annual temperature management plans. The initial stratification model shall be available for pilot application and evaluation no later than January 1, 2022. At the end of the three-year period starting once the stratification model is available, Reclamation and NMFS shall evaluate and confer on the model's accuracy and utility as a forecasting tool, and Reclamation will to decide whether implementation is appropriate.
- f. By December 31 of each year, Reclamation shall provide a hindcast of temperaturedependent mortality for winter-run Chinook salmon based on realized temperature management.
- g. Reclamation shall work with NMFS, USFWS and CDFW to complete a Battle Creek Acceleration Plan (Plan) by December 31, 2020. The plan shall address the Battle Creek Salmon and Steelhead Restoration Program and the Battle Creek Winter-run Chinook Salmon Reintroduction Plan. In the Plan, Reclamation will express a commitment to the Battle Creek Winter-run Chinook Salmon Reintroduction plan. The Plan also shall identify and express Reclamation support implementation of Battle Creek restoration, winter-run Chinook salmon reintroduction and for science actions such as marking and tagging/survival studies. The plan should, at a minimum:
 - i. Identify a suite of "no-regrets" actions that may be carried out while the disposition of the PG&E hydroelectric project is in process. For the purpose of this opinion, "no regrets" actions are defined as those actions that can move forward on Battle Creek that are not directly tied to future decisions related to the disposition PG&E's hydroelectric license on Battle Creek.
 - Support the designing and construction a fish trapping and sorting facility at Coleman National Fish Hatchery
 - iii. Identify ongoing monitoring and research needs -- The USFWS partners with the California Department of Fish and Wildlife for much of the monitoring for winter-run Chinook salmon on the Sacramento River. Service efforts include coded-wire tagging and marking Livingston Stone NFH-produced winter-run Chinook salmon, acoustic tagging a subset of those fish, rotary screw trapping at Red Bluff Diversion Dam, and carcass surveys on the mainstem Sacramento River. Reclamation covers the costs for all of the Service efforts, mostly out of the operational funding agreement for Coleman and Livingston Stone NFHs and the Reclamation monitoring agreement with the USFWS Red Bluff Fish and Wildlife Office. Both of these are long-term agreements with a history of renewal.
 - iv. Identify Livingston Stone NFH facility improvements necessary to support the Battle Creek Winter-run Chinook Salmon Reintroductin Plan.
- h. In order to minimize project related impacts to fish growth and survival on the lower Sacramento River, Reclamation shall complete the Fremont and Lisbon Weir Fish Passage Project by 2022 and will report out to NMFS on the progress of meeting project milestones. The anticipated schedule is described below:

- i. Implement the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project, as follows:
 - (a) Summer 2020 Preconstruction vegetation clearing and site preparation begins
 - (b) Summer 2021 Project construction
- ii. May 2020 Begin construction on the Agricultural Road Crossing 4 project
- iii. May 2022 Begin construction on the Lisbon Weir Fish Passage project

12. RPM 2: Reclamation and DWR shall minimize incidental take of listed species during operations in Clear Creek.

- a) To minimize incidental take under 60°F daily average water temperature criteria for adult CV spring-run Chinook salmon holding, and 56°F daily average water temperature criteria for CV spring-run Chinook salmon egg and embryo incubation, Reclamation shall, consistent with the proposed action and in consideration of Shasta Cold Pool Management:
 - i. Continue maintenance of temperature control curtains (Oak Bottom and Spring Creek) in Whiskeytown Reservoir.
 - ii. Through coordination with the Clear Creek Technical Team, consider real-time species information when making decisions regarding operational adjustments. This does not mean that the information will require operations to differ from what is contained in the final PA.
- b) Reclamation shall expand the Watercourse Engineering model water temperature in Clear Creek to capture the inter-connections of the Trinity-Sacramento river systems, including Whiskeytown Reservoir, to enable better temperature forecasting and planning in Clear Creek. Modeling inputs shall include water temperature impacts from hydropower peaking.
- c) Reclamation shall continue implementation of a weir annually to separate CV spring-run Chinook salmon and fall-run Chinook salmon during spawning to minimize the effects of redd superimposition and hybridization.
- d) To minimize the adverse effects of flow fluctuations associated with CVP-controlled water operations on all life stages of listed anadromous fish species in Clear Creek, Reclamation shall:
 - i. Coordinate flow release schedules with NMFS, USFWS, and CDFW via WOMT or B2IT or a comparable inter-agency fish monitoring group.
 - ii. Implement a down ramping rate of no more than 25 cfs per hour for controlled flow decreases from Whiskeytown Reservoir. This ramping rate is operationally feasible, and would reduce stranding risks to juvenile salmonids during controlled flow decreases. To further minimize stranding risk, Reclamation shall time down-ramping so the maximum rate of flow decrease occurs primarily during dark hours through the majority of the creek.

13. RPM 3: Reclamation and DWR shall minimize incidental take of listed species during operations of the American Division.

- a. Reclamation shall, in coordination with NMFS, USFWS, CDFW, and American River Group (ARG), develop and implement a plan to improve temperatures for all salmonids in the American River, using information from the value engineering report completed under RPA Action II.3 of the NMFS 2009 Opinion and other relevant information. A draft plan shall be submitted to ARG for review by August 1, 2023. A final plan, incorporating input from ARG and including recommendation for implementation, shall be submitted to NMFS by August 1, 2024. Seasonal operational decisions that affect water temperature and river flows shall be coordinated through the ARG.
- b. To minimize the adverse effects of flow fluctuations on listed anadromous fish species spawning, incubation, and juvenile rearing, Reclamation shall implement the following ramping rates. During periods outside of flood control operations and to the extent controllable during flood control operations, Reclamation shall ramp down releases in the American River below Nimbus Dam as follows, except as discussed with the ARG, including providing an opportunity for technical assistance by NMFS, and for the purposes of providing fish pulse flows that deviate from these levels:

Lower American River Daily Rate of Change (cfs)	Amount of decrease in 24 hrs (cfs)	Maximum change per step (cfs)
20,000 to 16,000	4,000	1,350
16,000 to 13,000	3,000	1,000
13,000 to 11,000	2,000	700
11,000 to 9,500	1,500	500
9,500 to 8,300	1,200	400
8,300 to 7,300	1,000	350
7,300 to 6,400	900	300
6,400 to 5,650	750	250
5,650 to 5,000	650	250
<5,000	500	100

14. RPM 4: Reclamation and DWR shall minimize incidental take of listed species during operations of the Eastside Division.

- a. The shift in compliance location from Ripon to Orange Blossom Bridge from June 1 to September 30 shall not go into effect until NMFS confirms that Reclamation has satisfied both of the following conditions:
 - i. Provide confirmation that a dissolved oxygen gage has been installed and is consistently providing accurate dissolved oxygen data at Orange Blossom Bridge.
- Reclamation shall complete the Final Temperature Management Study by December 31, 2024.

- c. Reclamation shall provide to NMFS an annual water temperature data set and may provide summary statistics at NMFS request.
- d. Reclamation shall provide to NMFS an annual report of incidental take associated with monthly temperatures, and provide an assessment of temperature conditions over the year including monthly average data at Orange Blossom. This information could be included in the Stanislaus Watershed Team annual report.
- e. To minimize the adverse effects of flow fluctuations on listed anadromous fish species spawning, egg incubation, and fry and juvenile rearing, Reclamation shall (during periods outside of flood control operations and to the extent controllable during flood control operations) ramp releases in the Stanislaus River below Goodwin Dam as follows:

Existing Release Level (cfs)	Rate of Increase (cfs)	Rate of Decrease (cfs)
at or above 4,500	500 per 4 hours	500 per 4 hours
2,000 to 4,499	500 per 2 hours	500 per 4 hours
500 to 1,999	250 per 2 hours	200 per 4 hours
300 to 499	100 per 2 hours	100 per 4 hours

15. RPM 5: Reclamation and DWR shall minimize incidental take of listed species during operations of the Bay-Delta Division.

- a. Consistent with the additional Delta measures on habitat restoration in the final PA (Section 4.10.5.12.3), Reclamation shall develop and implement a science-based nonnative predator management experiment to reduce the effects of mortality to emigrating juvenile salmonids related to seasonal operations and low flow conditions at key times and locations or "hot spots" in the Bay-Delta.
- b. Reclamation and DWR shall monitor the salvage of winter-run Chinook salmon, CV spring-run Chinook salmon, fall-run Chinook salmon, late fall-run Chinook salmon, sDPS green sturgeon, and CCV steelhead, associated with the operation of the CVP's Jones and SWP's Harvey Banks pumping facilities.
 - Reclamation and DWR shall monitor and calculate salvage and loss for winter-run Chinook salmon, CV spring-run Chinook salmon, CV fall-run Chinook salmon, CV late fall-run Chinook salmon, CCV steelhead, and salvage of sDPS green sturgeon at the TFCF and SDFPF.
 - (a) Reclamation and DWR shall prepare and submit to NMFS daily reports from October 1 through June 30 of each water year (or provide data online) regarding the observations of both salmonids and sDPS green sturgeon in the fish salvage facilities. Daily salvage sheets and the operational information needed to calculate salvage and loss shall be provided to NMFS (to a list of recipients updated each water year) or made available online. If, during the period from July 1 to September 30, salmonids and/or sDPS green sturgeon are observed in salvage, Reclamation and/or DWR shall notify NMFS through electronic mail and include

- the daily salvage sheets and operational information, or direct NMFS to where this information is available online.
- (b) During the October through June period of each water year, DWR and Reclamation shall prepare and submit to NMFS, DAT and DOSS weekly reports summarizing salvage and loss over the previous week and for the water year to date (or provide data online).
- (c) No later than December 31, Reclamation and DWR shall submit to NMFS an annual report summarizing salvage and loss over the previous water year (October 1-September 30).
- ii. Reclamation and DWR shall monitor salvage and loss for winter-run Chinook salmon, CV spring-run Chinook salmon, CV fall-run Chinook salmon, CV late fallrun Chinook salmon, and CCV steelhead, and salvage for sDPS of green sturgeon at TFCF and SDFPF. If the estimated rate of salvage or loss approaches the incidental take limit for any of the listed anadromous fish species, Reclamation and DWR shall immediately convene the WOMT to explore additional measures which can be implemented to reduce the rate of take and avoid exceedance of the incidental take limit.
- iii. Reclamation and DWR shall undertake tissue sampling programs from wild salmonids, and CWT samples from adipose fin-clipped juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead and CV late-fall run Chinook salmon at the TFCF and SDFPF, for genetic analysis or tag removal/reading pursuant to appropriate sampling protocols and statistical power analyses.
 - (a) Reclamaton and DWR shall submit incidental take reports from TFCF and SDFPF by December 31 of each year, to include the genetic results of the tissue samples.
 - (b) Reclamation and DWR shall develop and submit for review and concurrence by NMFS a plan for tissue and whole fish or head processing and storage by December 31, 2019.
- Reclamation and DWR shall minimize incidental take through best management practices at the fish facilities:
 - Reclamation and DWR shall develop and submit to NMFS for review within two years of issuance of the biological opinion (July 1, 2021) a protocol that outlines pumping restrictions and loss estimated during salvage disruptions at the TFCF and SDFPF.
 - ii. Reclamation and DWR shall standardize salvage, fish handling, and reporting protocols and provide opportunity for technical assistance by NMFS, except when required for structural differences between the fish salvage facilities. Standardized protocols for the SDFPF and TFCF shall be in place before the implementation of the PA. The protocols should also specify training procedures, QA/QC of data, and verification of records by third party inspection.

- iii. Reclamation shall develop, fund, and implement a plan for long-term improvements to the primary louvers at the TFCF, including methods for cleaning the louvers that do not reduce facility efficiency. A draft plan shall be submitted to NMFS by December 31, 2020. Contracting shall be completed by December 31, 2030. In the interim period, Reclamation shall develop a loss calculation that incorporates the decrease in louver efficiency during the period of louver cleaning to adjust the estimate of loss during the cleaning process when louvers are removed. This shall be completed within one year of the issuance of this Opinion (July 1, 2020).
- iv. In coordination with NMFS, FWS, CDFW, and the relevant technical teams, Reclamation and DWR shall develop and issue by December 31, 2019, a "Delta operations handbook" that provides clarification and detail on the information sources and calculations used to implement the various triggers for Delta operations.
- Reclamation shall incorporate the following terms and conditions related to DCC Gate Operations:
 - i. In order to streamline the decision process for implementing DCC gate closures based on the Knights Landing Catch Index and the Sacramento Catch indices, the catch indices shall be clarified to mean that greater than 3 fish per day is 3.00 fish and greater, and less than 3 fish is less than 3.00 fish per day. The greater than 5 fish perday is 5.00 fish and greater, and the less than 5 fish per day is less than 5.00 fish.
- e. Reclamation and DWR shall incorporate the following terms and conditions related to NBA/BSPP operations:
 - i. Cleaning of sediment from in front of the fish screens shall occur during the summer in-water work window of July 1 through October 31 or if ambient water temperature is greater than 77°F.
 - ii. Observers shall be present during sediment cleaning to look for entrained fish in the dredge material discharge as it is pumped into the dredge spoils pit. Any observed fish shall be collected and identified to species. If the species is a salmonid, total body length shall be measured and assigned to race by length at date using the Delta model. Tissue samples shall be collected all wild salmonids, and CWT samples from adipose fin-clipped juvenile winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead, for genetic analysis or tag removal/reading pursuant to appropriate sampling protocols.
 - iii. All observed sDPS green sturgeon shall be collected. Any living specimens shall be resuscitated if possible, and released away from the BSPP facilities. All dead specimens shall be retained, frozen, and NMFS notified for final disposition.
 - iv. Cleaning of aquatic weeds from in front of the fish screens shall occur during the inwater work window of July 1 through October 31 or when ambient water temperatures are greater than 25°C.
 - v. Observers shall look for any salmonids or sDPS green sturgeon entangled in the weed mass as it is placed in the trucks and as it is dumped in the disposal site area. Any observed fish shall be collected and identified to species. If it is a salmonid, total body length shall be measured and assigned to race by length at date using the Delta model. All observed sDPS green sturgeon shall be collected. Any living specimens shall be resuscitated if possible, and released away from the BSPP facilities. All dead specimens shall be retained and NMFS notified for final disposition.

- vi. An annual report shall be sent to NMFS-CCVO by December 31 of each year for the previous water year's operations. The report shall contain information regarding the dates of sediment removal or vegetation cleaning, the number of observed fish, including the number of salmonids and sDPS green sturgeon, if any, and the final disposition of the fish. If salmonids are observed, the report shall include the body lengths and run assignments for each fish.
- f. DWR shall incorporate the following terms and conditions related to the Predator Relocation Electrofishing Study/ Predatory Fish Relocation Study:
 - i. The initial "run" of Chinook salmon shall be determined based on length at date criteria if the fish is actually captured and handled prior to release.
 - ii. Information shall be collected, to the extent possible, regarding whether the fish have an intact adipose fin or not, and any external signs of sutures or an incision, indicating that it is a special study fish (acoustic tags).
 - iii. For those natural Chinook salmon captured, tissue samples shall be taken for DNA analysis and archived with CDFW.
 - iv. All salmonids and sDPS green sturgeon shall be immediately processed and returned to CCF in good health as quickly as possible.
 - v. If salmonids are observed in the electric field of the electrofishing boats, but are not captured, field crews shall note the approximate size and whether there is an adipose fin or not, if possible.
 - vi. When salmonids or sDPS green sturgeon are observed in the electric field, electrofishing shall stop in that area, and the boat shall move to another area of the CCF at least 400 yards away from the previous site, and DWR project managers shall be notified immediately.
- g. DWR shall incorporate the following terms and conditions related to the Aquatic Weed Control Program in CCF:
 - i. DWR shall provide notification of intent to conduct aquatic weed removal activities to NMFS at least 2 weeks prior to starting, including the types of herbicides intended to be used for that application and the areas that will be treated.
 - ii. DWR shall send copies of the water quality monitoring results for the concentration of herbicides in the CCF following treatment to NMFS within 10 business days of DWR's receipt of the results.
 - iii. DWR shall report to NMFS any fish observed exhibiting unusual behavior or found dead or moribund following herbicide treatment within 10 business days of the incident. All dead specimens shall be retained and NMFS notified for final disposition.
- h. DWR shall incorporate the following terms and conditions related to South Delta Agricultural Barriers:
 - DWR shall send notice of intent to construct the barriers to NMFS at least 14 days
 prior to start of construction. This information shall include anticipated start dates and
 completion dates for each of the barriers. In the fall, DWR shall provide NMFS with
 the anticipated schedule for removal of the barriers, and notification when the
 removal has been completed.
 - ii. DWR shall provide documentation to NMFS indicating the anticipated schedule for culvert operations, including potential early closures and water elevation conditions,

- by the completion of barrier installation each season. Updates to barrier operations shall be provided to NMFS on a weekly basis until mid-June.
- iii. DWR shall develop, in coordination with NMFS, structural improvements or alterations to the south Delta agricultural barriers to allow passage of adult CV spring-run Chinook salmon over the weirs in the spring. This may include notches in the weir, development of "temporary fish ladders" to be installed from May through June to assist passage, or other passage solution.
- iv. DWR, in coordination with NMFS, shall study the possible development of structures or alterations to the barriers to assist passage of sDPS green sturgeon through the locations of the south Delta agricultural barriers. If a tenable solution is found, DWR shall incorporate it into the design of the south Delta agricultural barriers.
- Reclamation and DWR shall confer with NMFS prior to making decisions to use storage releases for the Delta Smelt Summer-Fall Habitat action. The purpose of conferring is to avoid or minimize the potential for the action to reduce Shasta storage conditions necessary to for winter-run Chinook temperature management.

16. RPM 6: Reclamation and DWR shall minimize incidental take of Southern Resident killer whales during operations.

- a. Reclamation shall continue to support the USFWS' study of alternative release sites for Coleman NFH produced fall-run Chinook salmon for the next 2 years to determine if trucking to an alternative release site can increase juvenile survival to the ocean and adult returns to the Sacramento River without unacceptable levels of straying.
- b. Reclamation shall coordinate with the American River fish and water agencies to carefully consider protections for fall-run Chinook salmon while implementing the 2017 Flow Management Standard Releases and "Planning Minimum" for the American River.

7. RPM 7: Reclamation and DWR shall monitor the amount and extent of incidental take described in Section 2.1 as necessary to implement this Opinion.

a. Reclamation and DWR shall monitor the amount and extent of incidental take through the continued use of monitoring programs described in Appendix C of the BA and summarized below, which NMFS expects will continue without interruption. Reclamation and DWR also shall update Appendix C to describe how these monitoring programs will be used to monitor the amount and extent of take, how they will be applied to CVP and SWP water operation decision making and how they will be used for validation and effectiveness monitoring of Collaborative Planning actions.

i. Clear Creek

- (a) Adult Spring Chinook Escapement Monitoring in Clear Creek: video weir; snorkel surveys; life history sample collection (carcass)
- (b) Juvenile Spring-Run and Steelhead Production Monitoring in Clear Creek: rotary screw traps
- (c) Adult Steelhead and Late-fall Chinook Escapement Monitoring in Clear Creek: video weir and kayak redd counts
- (d) Operation of Clear Creek segregation weir (to separate fall and spring run Chinook salmon during spawning).

(e) Clear Creek habitat surveys.

i. Sacramento River

- (a) Red Bluff Diversion Dam Rotary Screw Trap Juvenile Monitoring Project: juvenile estimates for all Chinook salmon runs, lamprey, and sturgeon. Currently covered under an ESA Section 10(a)(1)(a) permit held by USFWS.
- (b) Juvenile Salmon Delta Emigration Real Time Monitoring: Sacramento and Chipps Trawl for salmonids. Currently covered under an ESA Section 10(a)(1)(a) permit held by USFWS. Listed as compliance for the NMFS 2009 opinion in the IEP Workplan.
- (c) Lower Sacramento River Juvenile Salmon and Steelhead Monitoring Project: rotary screw trapping at Knights landing. Currently covered under an ESA Section 10(a)(1)(a) permit held by CDFW. Listed as compliance for the NMFS 2009 opinion in the IEP Workplan.
- (d) Winter-run Chinook Salmon Escapement Monitoring: Carcass surveys
- (e) Spring, Fall, and Late-fall Chinook Salmon and Steelhead Escapement Monitoring in the Upper Sacramento River Basin: carcass surveys, aerial and wading redd surveys; video weirs, snorkel surveys in mainstem and major tributaries. Life history sample collection (carcass).
- (f) Upper Sacramento River Habitat Restoration Monitoring Project: project effectiveness surveys at habitat improvement projects (snorkel; video; electrofish; seine). Inclusion of steelhead at Red Bluff Diversion Dam screw trapping- O. mykiss counts are reported monthly.

ii. American River

(a) American River Chinook Salmon and Steelhead Escapement Estimation: carcass surveys, aerial and wading redd surveys.

iii. Stanislaus River

(a) Stanislaus River Chinook Salmon and Steelhead Escapement Estimation: carcass surveys, weir counts, and redd surveys.

iv. San Joaquin

(a) Mossdale Spring Trawl: trawl for juvenile steelhead and Chinook salmon. Currently covered under an ESA Section 10(a)(1)(a) permit held by USFWS. Listed as compliance for the NMFS 2009 opinion in IEP Workplan.

v. Hatchery

(a) Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatchery Programs.

vi. Delta

- (a) Fish Salvage Operations: Tracy and Skinner: daily salvage and loss; operational conditions, tissue sample collection. Tissue collection currently covered under an ESA Section 10(a)(1)(a) permit held by Reclamation. Included in IEP Workplan
- (b) Delta Juvenile Salmon Monitoring (DJFMP seines and trawls). Currently covered under an ESA Section 10(a)(1)(a) permit held by USFWS. Salmonid components listed as compliance for the NMFS 2009 opinion in IEP Workplan

- (c) Fall Midwater Trawl: Delta, Deep water shipping channel, and San Pablo Bay-Currently covered under an ESA Section 10(a)(1)(a) permit held by CDFW. Included in IEP Workplan.
- (d) Spring Kodiak Trawl- Currently covered under an ESA Section 10(a)(1)(a) permit held by CDFW. Included in IEP Workplan.
- (e) Estuarine and Marine Fish Abundance and Distribution Survey (Bay Study)-Currently covered under an ESA Section 10(a)(1)(a) permit held by CDFW. Included in IEP Workplan.
- (f) Tidal Wetland Monitoring Studies- Listed as compliance for the NMFS 2009 opinion in IEP Workplan.

vii. Multi Division

- (a) Genetic Identification of Salmonids to Inform Central Valley Project Operations and Bay-Delta Monitoring: For verifying winter and spring run. Sampling at fish facilities and monitoring programs to help with juvenile estimates; and larval fish ID at fish facilities. Tissue collection covered under Section 10(a)(1)(a) permit held by Reclamation. Included in IEP WorkplanOperation of Thermograph Stations- no take coverage necessary-USGS. Included in IEP Workplan
- (b) Enhanced Acoustic Tagging, Analysis, and Real-time Monitoring: Sacramento River through Delta for salmonids and sturgeon.
- (c) Funding or studies beyond collection of data (ototlith/scale collection). Genetics may be covered for all monitoring.
- (d) Adult sturgeon population estimates- covered under Section 10(a)(1)(a) permit held by CDFW. Included in IEP Workplan.
- b. Reclamation and DWR shall work with NMFS, USFWS, CDFW and the IEP Biotelemetry Project Work Team to review, consolidate, and accommodate researcher requests related to special handling of salvaged fish (e.g., release of ad-clipped sutured fish; checking for acoustic tags) unless not practicable. Reclamation and DWR shall respond to such consolidated requests at least annually to assist with planning for future years, and any denial of accommodation shall be explained in writing.
- c. Reclamation shall continue to support and develop SacPAS.
- 8. RPM 8: Reclamation shall minimize the incidental take of listed species associated by implementation of the proposed action by supporting the implementation of actions through the Collaborative Planning action component.
 - a. Reclamation shall convene an annual Director's meeting to review the past year's collaborative planning actions and coordinate on outyear planning.

9. RPM 9; Sacramento River Settlement Contractor measures

a. The Sacramento Settlement Contractors drafted for adoption a resolution for activities involving recovery projects, actions related to annual operations, and engagement in

ongoing science partnership. The SRS Contractors, in coordination with NMFS, shall continue to pursue activities in accordance with this resolution.

10. RPM 10: Reclamation and DWR shall coordinate with together and with NMFS to minimize incidental take of listed species related to coordinated operations.

a. Reclamation and DWR shall continue to integrate the Feather River Operations Group (FROG) into other CVP and SWP fishery monitoring groups.

2.12 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02 2007).

NMFS understands and expects that these projects will be partially or wholly funded by public funding sources such as the CVPIA program, the PCSRF/FRGP NOAA funds for salmon recovery and or State bond funds (e.g. Prop 1) in addition to PWA funds and other non-state and federal sources. NMFS further understands that each of these funding programs have their own processes, and expects Reclamation, DWR and local sponsors to compete for these funds. Furthermore, NMFS understands that PWAs will apply for funds, and if funded, implement several projects on this list.

- Reclamation and DWR should use the recovery plans for Central Valley Salmonids
 (National Marine Fisheries Service 2014b) and sDPS North American Green Sturgeon
 (National Marine Fisheries Service 2018g) to help identify and prioritize restoration and
 other Collaborative Planning actions that address the underlying processes that limit fish
 recovery by identifying high priority actions in the action area.
- Reclamation should consider the following list of Restoration, Technology, Science and Monitoring actions when implementing the Collaborative Planning and Scheduling components of the PA.

Restoration and Technology

- a. Reclamation, in coordination with the Clear Creek Technical Team, should identify and implement projects to restore the creek channel to one that is more responsive to the decreased magnitude high flow releases. Examples: lowering floodplains, removal of encroached riparian vegetation, creation of braided channels, all which improve would improve connectivity with the lower magnitude flows, increasing and improving the amount and quality of spawning and rearing habitat. This is intended to minimize impacts of controlled channel maintenance pulse flow releases, which are not high enough in magnitude and frequency to provide geomorphic processes that support connectivity and stream function in the current channel configuration, which thereby decreases optimal habitat for salmonids.
- b. Spawning Habitat Keswick to Red Bluff Diversion Dam; Objective Annually place 40,000 to 55,000 tons of gravel at the Keswick and/or Salt Creek injection site(s). Create

at least three site-specific gravel restoration projects upstream of Bonnyview Bridge by the end of 2024.

- c. Rearing Habitat Red Bluff Diversion Dam to Verona
 - i. Enhance at least 2,000 acres of floodplain habitat in the Sutter Bypass.
 - ii. Provide fish passage and floodplain habitat at Tisdale Weir within 5 years and Colusa Weir within 10 years.
 - iii. Inventory historic oxbows and design fish passage and floodplain projects within 5 years and implement projects within 10 years.
- d. Support fish passage improvements on Mill and Deer creeks.
- e. Support Nigiri North: Floodplain restoration in the lower Sutter Bypass.
- f. Reclamation should coordinate with NMFS on the planning and implementation of Delta Smelt Habitat Actions to maximize opportunity for multi-species benefits. For the purpose of this term and condition, coordination is not meant to infer NMFS concurrence with an action, but rather that NMFS is afforded the opportunity to provide scientific or technical recommendations for Reclamation's consideration.
- g. In additional to the 8,000 acres of the Delta Smelt Habitat Action, Reclamation and DWR should actively support the restoration of an additional 3,000 acres of tidal habitat for improved rearing and reduced reverse tidal flows in critical migratory channels.
- h. Reclamation and DWR should support the following Lower San Joaquin River Habitat Projects consistent with the Collaborative Planning Action described in the final PA (Section 4.12.3).
 - Restoration of floodplain access and San Luis National Wildlife Refuge
 - ii. Franks tract or other San Joaquin corridor specific restoration actions in the southern Delta
 - iii. Sturgeon Bend Floodplain Restoration
 - iv. Durham Ferry State Recreation Area floodplain restoration
- Reclamation and DWR should support the following physical and non-physical barrier projects.
 - Non-physical exclusion barrier at Georgiana Slough consistent with DWR's prior pilot study results.
 - ii. DWR Salmon Protection and Technology Study at Steamboat and Sutter Sloughs.
- j. Pursuant to the USFWS June 19, 2019 Letter providing an update on four efforts that the USFWS has been engaged in regarding Coleman and Livingston Stone National Fish Hatcheries and their contribution to the management and restoration of Chinook salmon in the Sacramento River and Battle Creek (Appendix C), Reclamation should work with USFWS to:

Secure an emergency/alternate water supply when Shasta and Keswick reservoirs reach elevations below the current penstock, or acquire (either purchase or rent) water chillers to ensure that adequate water temperatures are provided during critical winter-run Chinook salmon life stages (e.g., adult holding, egg incubation, and juvenile rearing).

i. Support the findings of a multi-agency teamed that concluded the need to expand by 8 to 10 circular tanks to raise an additional 350,000 fish if the hatchery were to engage in the same drought operations they did in the recent drought. Increasing the capacity

- of Livingston Stone NFH would require expanding to the west side of the hatchery road, additional piping to that side of the property, and additional water.
- ii. Coordinate with USFWS to evaluate the need for modifications or improvements to Keswick Dam Fish Trap and Elevator, or operational adjustments to reduce the likelihood of injure or death to adult fish entering or attempting to enter the trap.
- iii. Coordinate with USFWS to investigate the feasibility of installing an alternative winter-run fish collection facility on the south side of the Sacramento River at the ACID fish ladder. The study should begin in in January 2020. If the results of the investigation determine that a collection facility would be technically and economically feasible, Reclamation should install such a facility within 2 years of the recommendation.
- iv. Coordinate with the USFWS on the need to install a drum screen to remove solids from the hatcheries effluent. The purpose of the drum screen would be to provide more flexibility to use medicated feed to prevent disease.
- v. Support the construction of a fish sorting facility at the Coleman National Fish Hatchery

Science and Monitoring

- k. Fund science actions such as marking and tagging/survival studies for Battle Creek Reintroduction, spring pulse flow actions and for studying alternative release strategies for Coleman NFH fall-run.
- 1. Fund science, model development and monitoring; experimental design (with validation monitoring) for spring pulse flows and Anderson approach prior to operations.
- m. Reclamation and DWR, in coordination with NMFS, FWS, and CDFW, should develop, fund, and implement an updated plan for life cycle model development.
- n. Reclamation should update and recalibrate models to use recent data, especially that of the recent drought, to strengthen their ongoing application base for the purpose of minimizing the effect of take. Models that would benefit from recalibration include:
 - i. Loss-density method
 - ii. Delta Passage Model
 - iii. IOS model
 - iv. SWFSC Central Valley Winter-Run Chinook Life Cycle Model
- o. In order to reduce uncertainties regarding the mechanisms and extent of take in the form of juvenile salmonid behavioral modifications to hydrodynamic changes in the south Delta that are associated with water operations, Reclamation and DWR should, in close coordination with NMFS, using the Collaborative Science and Adaptive Management Program (CSAMP) and IEP processes:
 - i. Implement the recommendations of the CAMT 2017 workplan for salmonids (Collaborative Adaptive Management Team 2017). As part of this workplan, Reclamation and DWR should fund continued development of enhanced particle tracking modeling that is sensitive to realistic changes in south Delta operations, analyze existing data, and conduct experiments to assist in model development.
 - ii. Develop an adaptive management approach with a sound experimental design to test key alternative hypotheses (e.g., exports are important in additional to inflow in some circumstances in influencing juvenile salmon behavior, etc.). This experimental approach should build on lessons learned from VAMP, the six-year steelhead study,

and the CSAMP/CAMT gap analysis report and recent Delta salmonid research workshop (that occurred on May 22, 2018). The study design would likely need to test both more restrictive and less restrictive approaches to the current RPA, given low survivals in the South Delta. A power analysis should be conducted to determine the sample size necessary in order to detect the results we are looking for. This experimental operational approach could be paired with habitat restoration and or predator management actions/studies in the Delta and on the main stem San Joaquin River.

- p. Reclamation should consult with NMFS and CDFW to study, develop and implement an eight-year science-based predator hotspot management experiment.
 - f. The draft experimental design should be developed and submitted to NMFS for review by December 31, 2021. The plan should include proposed actions and locations and a funding and implementation strategy.
 - g. NMFS WCR and NMFS SWFSC should be consulted on the experimental design, including the objectives, scope, locations, timing, questions/hypotheses, and methods.
 - h. A final plan should be completed by June 1, 2022.
 - i. Actions may be taken as soon as possible but should begin no later than July 2022.
 - Reports summarizing the effectiveness of the experiment are due by July 2025, and July 2030.
- q. To improve the understanding of salmonid life-history in Clear Creek, and determine if salmonids produced in Clear Creek are successfully returning, Reclamation should develop genetic and otolith studies in coordination with the NMFS, CDFW, and USFWS, and provide funding. This information would help relate flow, temperature, and habitat restoration management actions to populations. The studies should also include non-listed fall-run Chinook salmon, which are prey for SRKW.
- 3. Reclamation and DWR should pilot some alternative techniques to quantify incidental take of listed anadromous salmonid species at the Federal and State export facilities, including at least one option developed under Term and Condition 2(a) of the 2009 NMFS Opinion.
 - a. In coordination with NMFS, Reclamation should design an initial pilot project to use existing alternative techniques, for implementation beginning October 1, 2020. During the pilot, official take should be based on the current estimation methods.
- Reclamation should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid and sturgeon habitat restoration projects within the Sacramento River Basin, Delta, and San Joaquin River Basin.
- Reclamation and DWR should make (or continue to make) all monitoring data collected under implementation of this opinion publicly available in order to facilitate integration with concurrent ecological monitoring efforts related to anadromous fish in the California Central Valley. The SacPAS website is an excellent example of how this is already being achieved for key monitoring data.

Reclamation and DWR should post interpretive signs and artwork characterizing local species and ecological function of nearby aquatic systems.

2.13 Reinitiation of Consultation

This concludes formal consultation for the Reinitiation of Consultation on the Coordinated Longterm Operation of the Central Valley Project and State Water Project. This opinion shall take effect after Reclamation signs a record of decision under the National Environmental Policy Act, and shall supersede the NMFS Biological Opinion on the Long-term Operations of the Central Valley Project and State Water Project (2009, as amended in 2011) at that time.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

The following provide specific reinitiation of consultation triggers pursuant to implementation of the proposed action.

- Limitations of Analysis regarding Shasta Dam Raise: As discussed in the effects
 analysis in this Opinion, Shasta Dam raise project as operated to the criteria in this PA is
 expected to have significant effects that have not been analyzed in this opinion. These
 include:
 - a. additional adverse effects to all juvenile salmonids due to reduced flood plain and channel margin habitats at certain times of years and locations that have not been analyzed, including reduced inundation of Yolo Bypass;
 - b. likely, but not assured, additional beneficial effects to winter-run Chinook salmon eggs due to reduced temperature dependent mortality in some years;
 - c. reduced inflow to delta in winter and spring and higher Delta inflow in summer and fall,
 - d. reoperation of reservoirs and delta pumps to deliver the newly stored water.

Therefore, NMFS expects that this consultation will need to be reinitiated prior to Shasta Dam raise operations.

2. Limitations of Analysis regarding water contracts: NMFS was informed by Reclamation as part of this consultation that the CalSimII modeling in the BA is based on historic use patterns of contractual water use. In some cases, this is significantly less than contractual water obligations listed in the PA. NMFS has only analyzed the contractual deliveries as modeled. Therefore, any significant changes to these patterns would likely trigger reinitiation of consultation.

3 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

3.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this Opinion are Reclamation and DWR (through the coordinated operations of the SWP with the CVP). Other interested users could include DWR, public water agencies, commercial and recreational fishing interests, environmental organizations, agricultural interests, and residents in California's Central Valley. An electronic copy of this Opinion was provided to Reclamation. The format and naming adheres to conventional standards for style.

3.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

3.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: Within the limitations of the aggressive consultation schedule imposed by the October 19, 2018, White House Memorandum on "Promoting the Reliable Supply and Delivery of Water in the West", this consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq.

Best Available Information: Within the limitations of the aggressive consultation schedule imposed by the October 19, 2018 White House Memorandum on "Promoting the Reliable Supply and Delivery of Water in the West," this consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this Opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA, and reviewed (albeit on an accelerated schedule) in accordance with West Coast Region ESA quality control and assurance processes.

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Biological Opinion for the Long-Term Operation of the CVP and SWP	
5	APPENDICES